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Information Sharing as a Competitive Supply Chain Strategy: Mapping the Various Antecedents

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The dissertation thesis was written independently and without the aid of unfair or unauthorized resources. Indications of sources are given whenever content was taken directly or indirectly from other sources.

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Preface

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Abstract

Motivation: Information sharing allows firms to improve their supply chain performance. Especially exchanging operational or strategic information such as inventory information or forecast information allows firms to improve their performance resulting in inventory reduction or better utilization of machine capacities. However, operational and strategic information sharing in supply chains varies as it is determined by different antecedents such as bargaining power, trust, or supply chain knowledge. For example, many firms do not share strategic information, as they fear opportunistic behavior from their partners. In contrast, supply chain partners share information mutually in case of aligned incentives and thereby realize mutual performance gains. Despite that, until today, there is little research on how various antecedents are inter-related and how the inter-play of various antecedents and their inter-relations affect information sharing in supply chains. To address this research gap, this thesis uses a fourfold qualitative research approach.

Research Approach: As a first step, an understanding of information sharing dimensions was obtained by analyzing two supply chain management information systems. Secondly, an exploratory case study was conducted to gain first insights on existing antecedents, their inter-relation, and their impact on information sharing in supply chains. Based on those findings, a matrix to organize antecedents on information sharing in supply chains for each form of information sharing has been developed from literature. In a fourth step, the matrix has been evaluated by using expert interviews and positivistic case studies. Next, a research model has been developed from literature incorporating previous findings to explain the inter-dependencies and the impact how antecedents affect information sharing in supply chains. Those findings are applied in the context of supply chain knowledge, connectivity costs of information systems, and within a pharmaceutical supply chain. Finally, we derive guidelines for managing information sharing in supply chains based on the concepts.

Results: The publications offer insights on how antecedents on information sharing are inter-related, how this affects information sharing in supply chains, and provides exemplary concepts to improve information sharing in supply chains within certain contexts. In specific, we identify initially how supply chain management information systems handle the exchange of information and explore how antecedents affect information sharing. The results allow us to select a game-theoretic perspective as suitable theory to develop a matrix. This matrix enhances researchers to organize antecedents on information sharing and to analyze their importance on supply chain information sharing. Further, the suitability of the matrix is given as it provides an explanation for the discrepancy between realizing the highest supply chain performance (by mutual information sharing) and having the highest risk to suffer from opportunistic behavior (in case of unilateral information sharing). Therefore, the matrix allows us to explain how antecedents and their inter-relations affect information sharing in supply chains. Building on that matrix, an explanatory model is derived to describe the inter-dependencies between the antecedents and their impact on information sharing. This model is evaluated by a single-embedded case study. Drawing from the tested explanatory model, concepts on how to organize the antecedents are developed for achieving mutual information sharing. The first concept applies our findings by proposing an ontology (supply chain knowledge) allowing

firms to collaborate and make knowledge accessible within a network. The second concept is related to information management capabilities as it identifies interfaces to ensure technical connectivity between information systems, RFID-systems, and supply chain members. The third concept develops a model that integrates consumers to improve the forecast accuracy by applying technical information management capabilities and supply chain knowledge. Finally, we propose guidelines for managing information sharing in supply chains depending on the current form of information sharing by considering the importance of antecedents on information sharing, their inter-relations, and the experience from developed concepts and tools.

Contribution: This thesis makes three key theoretical contributions: First, by developing a matrix derived from game theory to explain shifts in information sharing. The matrix allows researchers and practitioners to illustrate how antecedents influence information sharing considering the discrepancy between the highest risks to suffer from opportunistic behavior vs. realizing the highest supply chain performance. Second, by explaining inter-dependencies among the antecedents and their impact on information sharing. The developed research model allowed us to identify inter-dependencies and the importance of certain antecedents depending on the form of information sharing. In consequence, the matrix and research model can be used to align antecedents on information sharing towards mutual collaboration in supply chains. Thereby, this thesis contribute to theory by providing evidence for the applicability of the matrix and the research model to analyze information sharing in supply chains. Third, by applying the findings to derive insights and concepts on how the antecedents have to be managed. The application of findings provides examples how antecedents have to be organized to improve mutual performance. Practitioners can use the model and guidelines to align their information sharing processes and strategies to influence the level and amount of exchanged information for improving their supply chain performance.

Limitations: All research has limitations, and this thesis is no exception. First, and foremost, these thesis´ publications represent a period of more than three years. Therefore, evolvements in research and our understanding of the subject under study in respect to terminology, as well as concepts, and inter-relations has progressed. Second, while using a qualitative approach allows us to derive theories about specific phenomenon, further empirical testing is needed to ensure a broad manifestation within the researched field. Third, external factors and methodical limitations had an impact on the results covered in the attached publications.

Future Research: Industry specific influences should be investigated either in quantitative or qualitative settings to control for cross-industry variations. Especially quantitative research can further develop a research model to solve conflicting statements and test them for significance by using surveys. Thereby, quantitative research allows researchers to generalize the findings and determine significant linkages between the antecedents. In consequence, this would allow researchers to convert the matrix into a management tool for information sharing in supply chains as methodological weaknesses could be scaled down. Another option is a longitudinal case study to derive insight how antecedents affect and moderate information sharing in supply chains over time.

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List of Abbreviations

FTL	Full-Truck Load
IS	Information Systems
ISH	Information Sharing
IT	Information Technology
KPI	Key-Performance Indicator
LTL	Less-Truck Load
MC	Mutual cooperation
MD	Mutual defect
MISH	Mutual information sharing
NFC	Near-Field Communication
NISH	No information sharing
RFID	Radio-Frequency Identification
SCM	Supply Chain Management
SCP	Supply chain performance
SCOR	Supply Chain Operations Reference Model
SLA	Service Level Agreement
UC	Unilateral cooperation
UD	Unilateral defect
UISH	Unilateral information sharing

PART A: Introduction to the Dissertation´s Publications

1 Introduction

Information sharing allows firms to improve their supply chain performance resulting in higher revenues and margins (Klein & Rai, 2009). While transactional information sharing such as orders is mandatory to supply goods, operational and strategic information such as inventory information or forecasts allows firms to optimize their processes and realize increases in performance (H. L. Lee, So, & Tang, 2000; H. L. Lee & Whang, 2000). For example, Radio-Frequency Identification (RFID) technology increases data quality and the availability of operational information allowing firms to improve processes such as manufacturing, distribution, and transportation (Roh, Kunnathur, & Tarafdar, 2009; Roussos, 2006; Rutner, Waller, & Mentzer, 2004; Weinstein, 2005). In consequence, firms can enhance intra-organizational operations by sharing multiple information (Delen, Hardgrave, & Sharda, 2007; Fosso Wamba & Chatfield, 2009; L. Lee, Fiedler, & Smith, 2008). Therefore, operational and strategic information sharing is of importance for firms to improve their supply chain performance (Fawcett, Wallin, Allred, Fawcett, & Magnan, 2011; Klein & Rai, 2009).

Despite that, firms may avoid to share operational and strategic information as they fear opportunistic behavior from their partners (Nair, Narasimhan, & Bendoly, 2011), although the benefits of information sharing have been recognized and technological solutions facilitate information sharing within supply chains (Kogut & Zander, 1992; H. L. Lee, Padmanabhan, & Whang, 1997). Further, strategic information allow firms to influence terms and conditions in their own favor (Argyres & Liebeskind, 1999), resulting in various supply chain strategies in terms of information sharing among partners in supply chains (Gérard P. Cachon & Lariviere, 2001b; Patnayakuni, Rai, & Seth, 2006; Straub, Rai, & Klein, 2004). Besides the influence of bargaining power and the alignment of incentives (Gérard P. Cachon & Lariviere, 2001b; Fisher, Hammond, Obermeyer, & Raman, 1994; Straub et al., 2004), further antecedents such as trust, culture, organizational learning, and information management capabilities of firms have been identified to influence information sharing behavior in supply chains (Strong, Lee and Wang 1997, Lee, Padmanabhan and Whang 1997, Whipple and Frankel 2000).

Previous research found various antecedents that influence information sharing in supply chains by applying various theories, like the transaction-cost economics theory, agency theory, and property rights theory (S. M. Kim & Mahoney, 2006; Subramani, 2004; Villena, Gomez-Mejia, & Revilla, 2009). However, information sharing still differs among supply chains and firms (Prokesch, 2010). In practice, firms cope with various antecedents on information sharing such as organizational silos or alignment of information sharing strategies (Marchese & Paramasivam, 2013). From a theoretical perspective, various antecedents on information sharing have been identified, while research lacks a clear understanding on how antecedents influence information sharing, their inter-dependencies, and their importance for information sharing in supply chains (Ellram & Cooper, 2014; Fawcett, Fawcett, Watson, & Magnan, 2012; Kampstra, Ashayeri, & Gattorna, 2006). In consequence, a new theoretical perspective is needed that allows researchers and practitioners to explain differences in information sharing and inter-dependencies between antecedents on information sharing.

Since many of the supply chain related decisions and actions are often motivated by a selfish pursuit to maximize the firm's own benefits, valuable insights regarding the antecedents on information sharing are likely to be derived from game theory (Straub et al., 2004). Further, game theory is suited as it provides an explanation for the discrepancy between realizing the highest supply chain performance (by mutual information sharing) and having the highest risk to suffer from opportunistic behavior (in case of unilateral information sharing). Moreover, as game theory has seldom been used as a theoretical perspective to explain the antecedents on information sharing (Ellram & Cooper, 2014; Ketchen & Hult, 2007), this thesis uses a game-theoretic perspective to explain how various antecedents are inter-related, how the inter-play of various antecedents and their inter-relations affect information sharing in supply chains to develop supply chain information sharing strategies. To achieve the research objective, the following sub-objectives are formulated:

1. Identify dimensions of information sharing to explain what kind of information quality is needed and how much information needs to be shared between supply chain members to ensure the supply of goods and supply chain performance.
2. Explore and categorize relevant antecedents on information sharing
3. Identify a theory that helps to explain the reasons for a shift in the level of exchanged information.
4. Explain how relevant antecedents are inter-related and how the inter-play of various antecedents and their inter-relations affect information sharing.
5. Apply findings in the context of supply chain management to improve information sharing by proposing guidelines

This rest of the cumulative thesis is organized as follows. Part A consists of five chapters. The first chapters introduces this research. The second chapter provides an overview of the research approach by outlining the problem statement, stating the research questions, explaining the research strategy and used research methods. Further, the publications that make up this thesis are introduced and final remarks on the format are given. The third chapter recapitulates the theoretical background by introducing theories and antecedents, their relation to supply chain management and information sharing. The fourth chapter summarizes the findings of the publications in Part B, followed by outlining the implications for theory and practice and the limitations and opportunities for future research. The fifth chapter summarizes Part A. Part B comprises the nine publications that were published[1] in the context of this thesis. Part C includes the developed and used questions and coding scheme for the conducted the case studies as appendix.

[1] Eight publications are already published, while one publication is in the 2nd review round (revise and resubmit) and one publication is work in progress. See Part B for details.

2 Research Approach

Within the first section of the second chapter, the objective of the thesis is broken down into five research questions. In addition, the author provides for each research question a detailed overview of the problem and states how the results allow the author to formulate the successive research question making a link to the objective of the thesis. While the second section describes how different research methods were used for answering the objective of the thesis, the third section explains used research methods in detail. The fourth section allows the reader to recognize how the publications allow the author to answer the aforementioned objective of the thesis. Finally, some remarks are given.

2.1 Detailed Problem Statement and Research Questions

In the following, each research sub-objective is motivated by one problem statement. Further, each problem statement is explained in detail and a research question is developed.

<u>Problem statement 1:</u> *There is no clear understanding on which mechanisms enable supply chain information systems to share relevant, accurate, and timely information between supply chain partners.*

Access to timely, relevant, and accurate information allows supply chain members to react upon changes within the supply chain and influence the supply chain performance positively (H. L. Lee, 2002; Rai, Patnayakuni, & Seth, 2006). Relevant information can be used for supply chain related decision-making (Gulati & Kletter, 2005; 2007) in case the quality of shared information is high, without errors, and accessible in a timely manner (Straub et al., 2004; R. Y. Wang & Strong, 1996). Further, information systems can support information sharing processes in supply chains by making use of technological innovations such as supply chain information systems or inter-organizational information systems (Christiaanse, 2005). Despite that knowledge and technological innovations, supply chains suffer from late information, being not relevant, and of poor quality (Patnayakuni et al., 2006; Straub et al., 2004). While firms recognize the importance of information sharing and the requirements for information sharing differ, there is a need to analyze which mechanisms enable information sharing and how information systems contribute to information sharing in supply chains. Therefore, the first sub-objective is guided by the following research question:

> <u>**Research question 1:**</u> *What are appropriate dimensions of supply chain information systems that enable information sharing between supply chain members?*

Having first insights on information sharing dimensions, we analyzed the antecedents on information sharing. Information sharing enables firms to realize cost savings and thereby improve supply chain processes (Theodore H. Clark & McKenney, 1994; Enslow, 2006). In consequence, information sharing has been recognized as essential factor for supply chain performance (H. L. Lee et al., 2000; Rai et al., 2006). However, firms may still avoid sharing information with their partners (Ellram & Cooper, 2014; Karen, 2010; H. L. Lee et al., 1997), as operational and strategic information provides firms with the ability to influence terms and conditions in their own favor (Argyres & Liebeskind, 1999; Nair et al., 2011).

<u>Problem statement 2:</u> *Current research lacks a clear understanding of existing antecedents on information sharing and a clear classification to analyze their importance for information sharing.*

The lack of coherence in the field of supply chain management is visible by comparing theoretical findings and firms´ behavior in practice (Ellram & Cooper, 2014). Researchers are at the beginning of the journey (Ellram & Cooper, 2014), identifying barriers, benefits, and bridges towards supply chain collaboration (Fawcett et al., 2012; Fawcett, Magnan, & McCarter, 2008a). In contrast, firms cope with problems such as information visibility (among partners and within firms), collaboration with supply chain partners, or creation of supply networks (Koperdraat & Dieteren, 2013). Examples from real life supply chains indicate that different factors play a role in how information is shared.

For example, Dell uses its strong bargaining power position to integrate upstream partners and apply daily information sharing routines. This allows Dell to improve their supply chain performance by realizing a negative cash-conversion cycle of five days and other process improvements (Magretta, 1998). The Spanish clothier Zara maintains a supply network with strict rules and processes ensuring appropriate upstream information sharing twice per week, resulting in efficient supply of products. All Zara stores have to abide by the pre-defined network rules, document the information using various prescribed techniques and share information accordingly. As a result, Zara is able to achieve a high responsiveness in its supply chain and above industry average margins (Ferdows, Lewis, & Machuca, 2004). Toyota relies on the daily sharing of the minimum required operational information with its upstream partners to achieve a robust, simple and productive system (Black, 2007).

In addition to this, Toyota established rules and norms allows and stimulates each member of the network to access and share strategic information like production related knowledge (costs, quality, inventory, etc.). Such knowledge is viewed as the property of the whole network. This enables suppliers to enhance their efficiencies by making use of the knowledge residing in the network, and at the same time Toyota enjoys the highest gain owing to a more efficient network because of its strong position (Seidmann & Sundararajan, 1997). While the integration of suppliers into the network increases their bargaining power, the increased asset interconnectedness resulting from the integration also acts as safeguard for the relationship (Dyer & Nobeoka, 2000; Nair et al., 2011).

The above examples indicate that information sharing is determined by different antecedents. Previous research identified further antecedents on information sharing such as trust, culture, bargaining power or contracts (Fawcett et al., 2008a; Kampstra et al., 2006; Patnayakuni et al., 2006). Further, information management capabilities of firms (Mithas, Ramasubbu, & Sambamurthy, 2011; Rai et al., 2006; Strong, Lee, & Wang, 1997) and their (socio-) political behavior (K. Kumar & van Dissel, 1996; H. L. Lee et al., 1997) are antecedents influencing information sharing in supply chains. Information management capabilities ensure factors such as the accuracy of data and the timeliness of information (Malhotra, Gosain, & El Sawy, 2007; Simatupang & Sridharan, 2005). Socio-political antecedents influence economic decisions such as to make supply-chain specific investments, cultural factors such as inter-firm learning processes (Doz, 1996; Dyer & Nobeoka, 2000; N. Kumar, 1996; Nair et al., 2011), supply chain knowledge about business processes along the supply chain, and the (technical) ability to apply it within the supply chain (Hult, Ketchen Jr, & Slater, 2004; Richard & Devinney, 2005). Another antecedent that can influence the success of supply chain partnerships is trust (Whipple & Frankel, 2000). Trust characterizes the social aspect of (supply chain) partnerships or alliances. Therefore, trust inter-relates as adhesive, flexible and informal tie between socio-political and political behaviors (Shub & Stonebraker, 2009).

Despite that, identified antecedents with similar attributes are (1) named differently and (2) just represent a loose listing such as enablers and resistors (Fawcett et al., 2012) showing that there is no rich theoretical grounding for antecedents on information sharing (Ellram & Cooper, 2014). For example, Fawcett et al. (2008a) classifies the antecedents as inter-firm and managerial rivalry further being composed of factors such as IS/IT deficiencies, lack of channel trust, or internal and external turf wars. In contrast, Kampstra et al. (2006) lists IT infrastructure, trust, and powerhouses as exemplary antecedents on information sharing. Furthermore, it is even not clear which antecedents are important to enable information sharing and thereby contribute to supply chain performance. For example, while Ho-Chang, Chang, and Prybutok (2014) found no significant link between information management capabilities and firm performance, Rai, Pavlou, Im, and Du (2012) suggest the opposite.

In consequence, findings from research contribute little towards explaining which antecedents determine information sharing in supply chains, and their importance for information sharing (Emberson & Storey, 2006; Ketchen & Hult, 2007). In practice, information sharing in supply chains differs, as firms still suffer from various issues such as organizational silos, political games, or missing supply chain knowledge; reflecting high barriers to achieve information visibility and transparency through information sharing (Karen, 2010; Marchese & Paramasivam, 2013; Prokesch, 2010). Therefore, our second research question is as follows:

Research question 2: *What are antecedents of information sharing, how can the antecedents be categorized to explain differences in supply chain information sharing behavior?*

Collaboration within supply chains might lower the benefits of individual firms within the supply chain in comparison to the overall supply chain performance (Ba, Stallaert, & Whinston, 2001). In that case, especially monetary incentives are of importance to initiate partnerships (Theodore H Clark & Lee, 2000). Therefore, firms need align collaboratively the antecedents among partners (Fawcett et al., 2012; Fawcett, Ogden, Magnan, & Cooper, 2006). In consequence, information sharing across partners needs to be rewarded by distributing risks and costs equally to ensure a fair distribution of benefits across the supply chain (Narayanan & Raman, 2004). However, the dilemma faced by firms is whether to use the information egoistically or co-operatively (Fawcett, Magnan, & McCarter, 2008b).

<u>Problem statement 3:</u> *As information sharing is determined by various antecedents, it is necessary to analyze how game theory can be used to analyze information sharing in supply chains.*

Theories such as the agency theory, the network theory, or the resource-based view analyze information sharing in supply chains. However, in case of the agency theory, supply chains are simplified to a one-on-one relationship, reflecting one buyer and one supplier (Voigt & Inderfurth, 2012). Therefore, the analysis is limited. For example, in case of two employees, one at the buyer´s side, and one on the supplier´s side, managerial effects cannot be considered. Further, the network theory is limited as it is mostly complimented by the transaction costs economics theory to include financial aspects (Jraisat, Gotsi, & Bourlakis, 2013; Patnayakuni et al., 2006). Moreover, the resource-based focuses on internal processes and strengths of firms (Agan, 2012; Amit & Schoemaker, 1993), while it misses to emphasize a collaborative perspective to analyze processes from a supply chain relational perspective.

Game theory allows analyzing and conceptualizing various antecedents on information sharing. Further, magnitude and symmetry of information sharing can be reflected in a game-theoretic setting. Thereby, bargaining power differences and its effects on information sharing among supply chain members can be studied (Straub et al., 2004). However, previous research has focused towards using game theory as quantitative research approach such as for calculating the buyer-supplier pay-offs (e.g., Gerard P. Cachon & Netessine, 2004; Nair et al., 2011; Simchi-Levi, Wu, & Shen, 2004). We believe that using a qualitative approach towards analyzing supply chain behavior by adapting basic game theoretical concepts is feasible for understanding the antecedents on information sharing (Heide & Miner, 1992; Parkhe, 1993a, 1993b).

In consequence, we can state that game theory is suited to provide an explanation for the discrepancy between realizing the highest supply chain performance (by mutual information sharing) and having the highest risk to suffer from opportunistic behavior (in case of unilateral information sharing). Therefore, we use the simplest form of game theory (the prisoners´ dilemma) as theoretical foundation for analyzing antecedents on information sharing in supply chains; thereby explaining shifts in the level of exchanged information.

<u>**Research question 3:**</u> *How can game theory be used to organize antecedents on information sharing and help to explain a shift in the level of exchanged information?*

Previous research analyzed information sharing from various perspectives analyzing exchange relationships in which partners behave opportunistically (Williamson, 1985, 1993). In contrast, Macneil (1980) and Uzzi (1997) emphasize on the role of trust as critical to foster and maintain value-enhancing inter-firm relational exchanges. While previous research has provided significant insights (Goo, Kishore, Rao, & Nam, 2009; Rai, Keil, Hornyak, & Wüllenweber, 2012), it misses to analyze joint influences affecting supply chain collaboration.

Problem statement 4: To analyze antecedents on information sharing in supply chains, inter-relations and inter-dependencies between antecedents have to be considered.

Further, as research mostly controls only for a small aspect, inter-relational effects of antecedents on information sharing are not analyzed (Rai, Keil, et al., 2012; Van der Vaart & van Donk, 2008). For example, in reality, varying factors such as bargaining power, contracts, or trust determine information sharing in supply chain relationships (Kampstra et al., 2006). In addition, the role of information management capabilities for explaining information sharing behavior within supply chain relationships has been highlighted (Mithas et al., 2011; Rai et al., 2006). Information management capabilities of firms in a supply chain relationship ensure technical aspects, accuracy and timeliness of information, and therefore contribute towards connectivity of supply chain information systems, the quality and effectiveness of information sharing (Malhotra et al., 2007). However, it is still not clear how relational or political factors jointly determine information sharing behavior in supply chain relationships (Kampstra et al., 2006; Rai, Pavlou, et al., 2012).

In supply chain management, the bullwhip-effect illustrates an exemplary supply chain problem of firms coping with cooperation and competition as a result of inter-dependency between antecedents such as incentive structures, trust or timeliness of information (H. L. Lee, Padmanabhan, & Whang, 2004). A dilemma faced by the supply chain partners is whether to maximize their own interest or the interests of the supply chain as a whole. A short-term individual partner's self-interested choice, albeit rational, will lead to a failure of a collaborative supply chain; which therefore pose a social dilemma for each of the partners (Dawes, 1980; Fawcett et al., 2008b; Yamagishi, 1986). This may result in rational but uncooperative behavior, shortage gaming (Gérard P. Cachon & Lariviere, 1999; H. L. Lee et al., 1997) and threats for firms such as high inventories, stock-out situations or markdown of products (Straub et al., 2004). The presented dilemma stresses the need and importance to identify the inter-dependencies of antecedents on information sharing to improve supply chain performance (Fawcett et al., 2008b; Johnson, Elliott, & Drake, 2013). However, dynamic elements in supply chain collaborations increase the complexity to organize the antecedents on information sharing (Fawcett et al., 2012).

We address this gap by analyzing how various antecedents such as bargaining power, supply chain knowledge, or trust are inter-related and how the interplay of various antecedents and their inter-relations affect information sharing in supply chains using a qualitative approach. Therefore, our fourth research question is as follows:

Research question 4: *How is the inter-relation of antecedents on information sharing and how do these inter-relations affect information sharing in supply chains?*

Identifying the inter-relations of antecedents on information sharing provided us with the possibility to apply the findings. In specific, we applied supply chain knowledge, information management capabilities, and a combination of them. While current supply chain management research misses to provide a rich and theoretical grounding (Ellram & Cooper, 2014), we apply only one antecedents on its own, focus on its effect, and thereby improve the reliability and validity of the findings. Furthermore, we apply our findings in specific contexts and derive guidelines. We validate our guidelines by conducting a final case study using a synopsis of all of our findings. This process allows us to provide applicable guidelines for improving information sharing among supply chain partners.

Problem statement 5: Inter-relations and inter-dependencies between antecedents on information sharing have to be applied to propose supply chain information sharing guidelines.

Application of supply chain knowledge: Changing customer needs, shorter product-life cycles, increasing competition in a globalized world create the need for quick, agile and flexible response time in supply chains (H. L. Lee, 2002; Thomas & Griffin, 1996). Therefore, supply chain partners need to collaborate in order to solve the described challenges. New technologies allow firms to collaborate, share, and organize information (Chui, Miller, & Roberts, 2009), while managing the supply chain with all upstream and downstream partners requires a platform to collaborate (Ooi, Chong, & Tan, 2011). In consequence, supply chain members need help to conserve and extend their supply chain knowledge and make it accessible among supply chain members in order to design, plan, and steer supply chains more efficiently (Fawcett et al., 2008a). More specifically, as previous research lacks issues such as interoperability among supply chain information systems (Douligeris & Tilipakis, 2006), or miss to address dynamic aspects in supply chains (Fayez, Rabelo, & Mollaghasemi, 2005), there is a need to develop an ontology based platform to realize cooperation providing the same level of supply chain knowledge for all supply chain members (Samuel, Goury, Gunasekaran, & Spalanzani, 2011).

Application of information management capabilities: Radio frequency identification (RFID) technology is one opportunity that allows firms to improve availability and quality of information resulting in a better information visibility among supply chain partners (Fosso Wamba & Chatfield, 2009; L. Lee et al., 2008). Therefore, firms who integrate RFID systems and (new) business processes into existing information technology (IT) systems can benefit from a higher availability and quality of information (Strueker & Gille, 2008). However, connecting systems and setting up unique and complex business processes among supply chain partners is difficult (Angeles, 2005). In particular, firms need information management capabilities to define general and specific objectives for connecting systems, integrating hardware and software, developing additional code for specific requirements (such as additional applications), and calculating costs upfront (Hartman & Ashrafi, 2002; Reel, 1999; Smithson & Hirschheim, 1998). In particular, software integration costs for connecting RFID systems with existing information systems range from 22% (Maurno, 2005) to over 80% (Trunick, 2005) of the total project costs. Further, existing practitioners guidelines are limited to general illustrations of RFID technology not considering system integration costs (Angeles, 2005; Karkkainen, 2003). Therefore, we contribute to a better understanding of costs upfront for connecting supply chain information systems from a supply chain perspective (Asif & Mandviwalla, 2005).

Applying an integrative view of the supply chain: This study applies information management capabilities and supply chain knowledge towards an inter-organizational view for a pharmaceutical supply chain. As it is predicted that the application of RFID in healthcare will increase (Fichman, Kohli, & Krishnan, 2011) and the percentage of elderly people in Germany growths, it can be expected that there is a rising demand for health care products including medication and services such as individual information on specific dosage or side-effects of drugs (AOK Bundesverband, 2011). RFID technology allows to store information online or directly on the RFID tag (Wiles, 2007) and enrich tagged products during the handling process at each supply chain member with additional information such as side-effects (Ngai, Cheng, Au, & Hung Lai, 2007). Further, RFID technology can be combined with sensors enabling supply chain partners to monitor and store conditions such as temperature or expiry date of drugs (Blecker & Huang, 2008). Moreover, RFID technology can prevent patients from taking counterfeit products and manufacturers loosing revenues (Chien, Yang, Wu, & Lee, 2011). Counterfeit drugs results in financial damages, stock-out situations and also health risks (Rekik, Sahin, & Dallery, 2009).

Synthesizing the findings: To develop information sharing guidelines for supply chains, we need to analyze and synthesize our qualitative data, findings from prototypes or concepts, and previous knowledge within the research community. However, as some of the findings are contrary, we conduct an additional case study within the aircraft industry to validate their applicability. Based on the problem statement, the fifth research question is as follows:

Research question 5: *How can the findings be translated towards information sharing guidelines for supply chain relationships?*

Section 2.4 provides an overview on how the publications included in the dissertation support the overall research objective, and on how each publication contributes to answer a research question, thereby contributing to a sub-objective. Within the next section, the applied research strategy to answer the research questions is presented, followed by a general description of used research methods. Further, chapter four summarizes and discusses the findings of the publications and their contribution to the specific research question.

2.2 Research Strategy

This thesis follows an inductive research strategy using a five-fold approach combining qualitative research, systematic analysis (literature review), and design science: First, we examined information sharing in supply chains. Second, we conducted an explorative case study, followed by a structured literature review. Third, we used our findings to develop our information sharing matrix and develop hypotheses. Fourth, we conducted an explanatory case study to validate the hypotheses and thereby our matrix. Fifth, we applied the findings to derive guidelines for information sharing in supply chains.

Qualitative research allows researchers to explore and explain phenomenon by gathering and analyzing rich data such as transcripts, documentations, or simply by observing people´s behavior (Yin, 2009). Further, as polarity makes phenomenon more visible and evident than in similar contexts, we chose polar supply chains to observe and study antecedents on information sharing in supply chains in depth (Eisenhardt, 1989b; Pettigrew, 1990). To enrich our first insights from the explorative case study and gain a better understanding of antecedents on information sharing, their inter-dependencies and their impact on information sharing, we conducted a literature review using the guidelines from Webster and Watson (2002).

We used this knowledge to develop the information sharing matrix and hypotheses, to refine the semi-structured interview questions, and to derive code words for analyzing the transcripts from the case study. This allowed us to study dynamics and inter-relations of determinants on information sharing (Eisenhardt, 1989b; Locke, 2001; Yin, 2009). In consequence, our results provide a valid sample that allows replication of findings, the extension and complementation of theory (here: game theory), and application of findings (Eisenhardt, 1989b; Hesse-Biber, 2010, p.4). Further, our results contribute to breadth and depth of findings within the discipline of supply chain management (Ellram & Cooper, 2014)

2.3 Research Methods

Within this section, general information on the used research methods (literature review, case study, and design science) are given, on how we applied the methods, and on how its usage contributed to the findings.

2.3.1 Literature Review

Conducting a literature review enables researchers to review and create a firm base for advancing knowledge. Thereby it fosters theory development, and makes areas for research evident (Webster & Watson, 2002). To identify relevant papers, we used a concept-centric approach applying a structured procedure as recommended by Webster and Watson (2002).

We prepared the first step by identifying appropriate databases such as EBSCO-Host or ACM for the search ensuring to cover all leading journals and leading conferences in the field of research. In addition, we extended our search by using Google Scholar to ensure a broad selection to include minor conferences and other sources.

As a first step, we defined key words for our search reflecting the context and level of analysis (Whetten, 1989), followed by a first and second review process. While the first process focused on reviewing the title, the abstract, the keywords, and the conclusion, the second process narrowed down relevant articles by reviewing the complete text. The third step represents a forward and backward analysis.

This thesis reviewed existing literature within the fields of supply chain management, information management, and general management. The relevant literature was identified using the keywords supply chain, SCM, inter-organizational, information sharing, knowledge sharing, collaboration, alliances, antecedents, factors, barriers, and various modifications. This analysis helped us to improve our understanding of antecedents on information sharing, and to refine our interview guidelines for the explanatory case study.

2.3.2 Case Study

Case studies are one method of doing social science research to illuminate decisions or phenomenon. Thereby case studies focus on "how" and "why" questions, and in case the researcher has little or no influence on events. Furthermore, case studies are used to analyze phenomenon in real-life contexts (Yin, 2009). In consequence, case studies enhance researchers to improve our understanding of complex phenomenon by analyzing individual, group, organizational, social, political, and related phenomenon. The ability of handling and analyzing a full variety of evidence can be considered as strength of case studies. In addition, case studies allow researchers to combine multiple methods such as surveys or experiments in any case study (Yin, 2009).

Further, case studies can be differentiated by its descriptive, explorative, or explanatory setting. While descriptive case studies describe a state or condition, exploratory case studies can be used to develop propositions for further inquiry. In contrast, explanatory case studies are advantageous when researchers analyze relations such as inter-dependencies of antecedents. Therefore, case study research can be applied in real situations where phenomenon shall be analyzed in depth (Yin, 2009).

The research design of case studies consists of a six-fold approach: (1) plan, (2) design, (3) prepare, (4) collect, (5) analyze, and (6) share. For the first step, researchers have to develop a study´s question (or proposition) from theory, define the unit of analysis, and prepare the collection of evidence and its analysis (Yin, 2009). In consequence, validity of results can be ensured (Eisenhardt, 1989b; Yin, 2009).

As this thesis used exploratory and explanatory case studies, we used research questions for our exploratory case studies, and evaluated hypotheses in our explanatory case study. For all case studies, we developed a semi-structured interview guideline. This guideline was checked by independent researchers and by employees from consulting firms. Further, the guideline was developed iteratively during the process considering findings.

Moreover, in all cases, the unit of analysis were supply chains with upstream and downstream partners. However, due to availability of data (here: cases), we conducted two single case (embedded) design case studies, and one multiple case (holistic) design case study. Single case study design can be used to confirm, challenge, or extend theory, while multiple case study design can be used to address rival explanation and therefore build a base for future case studies.

Based on previous literature, we explored rival explanations for differences in information sharing in supply chains using replication logic within the multiple case study design (Publication 2); thereby contributing to first insights on antecedents on information sharing in supply chains. In addition, the first single case (embedded) case study (Publication 5) confirms theory by evaluating our hypotheses; the second single case (embedded) case study extends theory by proposing guidelines for information sharing in supply chains (Publication 10).

For the analysis, we collected multiple data such as screen-shots, internal descriptions, and observed behaviors. We used the following process for the explorative case studies: We analyzed the data with the involved researchers, and discussed controversies. In case controversies could not been solved, we conducted follow-up interviews. This allowed is to derive propositions. For the explanatory case study, we traveled back and forth (in a three-fold process) between our data allowing us to evaluate our hypotheses (Locke, 2001; Michael G. Pratt, 2009; Strauss & Corbin, 1998).

In a *first* step, we developed theoretical dimensions from the literature being used as base to adapt the semi-structured interview guideline (Locke, 2001). Using findings from the first case study, we validated and enriched the theoretical dimensions, formed provisional categories and some initial first-order codes by applying a bottom up open coding process (Locke, 2001; Michael G Pratt, Rockmann, & Kaufmann, 2006; Strauss & Corbin, 1998). Provisional categories were consolidated and theoretical dimensions were derived, representing the move from open to axial coding (Locke, 2001; Strauss & Corbin, 1998). This first step resulted in a data structure with theoretical dimensions, theoretical categories, and first-order codes.

In a *second* step, inter-dependencies were identified by using an induction and deduction approach revisiting the data in a second step (Locke, 2001; Michael G Pratt, 2008). Independent coding of data such as internal documents, screen-shots, and observations allowed us to resolve rival statements (Krippendorff, 2012; A. S. Lee & Baskerville, 2003; Yin, 2009). Hence, we comply with quality criteria (validity of results) for case studies suggested by Yin (2009).

In a *third* step, we aggregated our findings allowing us to identify inter-relations between antecedents on information sharing, and their impact on information sharing in supply chains. Further, our findings enhance us to explain importance of antecedents for information sharing in supply chains, and provide an explanation on how antecedents have to be aligned to ensure mutual information sharing in supply chains. Thereby, using case study research helped us to analyze a real-world problem and provide suggestions on how to solve it.

2.3.3 Design Science

Design science research is technology-orientated research that allows researchers to apply the scientific knowledge base by building artifacts and evaluating them against criteria of value or utility (Briggs & Schwabe, 2011; March & Smith, 1995). Therefore, constructs, models, methods, or guidelines are outputs and can be referred to as design artifacts (March & Smith, 1995). Artifacts can be developed from the scientific knowledge base such as theory or observations (Nunamaker Jr, Chen, & Purdin, 1991). In this thesis, we apply scientific knowledge (theory: fourth publication; and observations from exploratory and explanatory case study research: second and fifth publication) for solving practical problems such as knowledge management in supply chains (Briggs & Schwabe, 2011).

For the development process, we draw on the three cycle view for the design of information systems that comprises the relevance cycle, the design cycle and the rigor cycle as proposed by Hevner (2007). While the relevance cycle relates practical problems with the design of artifacts, the rigor cycles ensures that the design process of the artifact is based on scientific knowledge. Further, the design cycle represents the iterative cycle between designing and developing the artifact, using scientific knowledge for further refinement of the artifact, and contributing to the scientific knowledge base by sharing additional insights such as guidelines (Hevner, 2007; Hevner, March, Park, & Ram, 2004).

Therefore, we used an iterative process to design, build/develop/refine, and evaluate our artifacts. As design and evaluation methods can be (1) observational, (2) analytical, (3) experimental, (4) testing, and (5) descriptive (Hevner et al., 2004), we applied observational (eighth publication), testing (seventh publication), and descriptive (ninth publication) methods.

We used observational design and evaluation methods to ensure that firm can use our artifact to calculate connectivity costs for inter-organizational information systems. In specific, we adapted field studies by using cognitive walkthrough methods in an iterative evaluation process. The cognitive walkthrough method is recommended for practicing software developers without background in cognitive psychology, and only some experience in interface evaluation. The method enables developers to evaluate their artifact and identify problems (Wharton, Rieman, Lewis, & Polson, 1994). Further, the cognitive walkthrough method can be considered as helpful in the case of a complicated cross-functional domains such as RFID (Granollers & Lorés, 2006). In addition, the cognitive walkthrough method allows developers to make mismatches between implicit and explicit expectations of users more evident (Granollers & Lorés, 2006; Wharton et al., 1994). This process allowed us contribute to a better understanding of cost drivers and business processes that influence connectivity between supply chain information systems.

By using testing methods, we were able to ensure an appropriate structure of the ontology for the platform (structural testing), and by executing the platform, we confirmed the functionality. Considering recent research from the fields of supply chain management and information systems for the development of the ontology and platform reflects that the artifact uses scientific knowledge to solve the practical problem. Thereby applying structural testing methods to ensure rigor and relevance of the platform. In addition, we ran internal functional tests with the platform to discover failures and defects. This artifact adds scientific knowledge on how supply chain knowledge and specific supply chain information have to be used among supply chain partners to realize better supply chain performance.

We used descriptive design and evaluation methods to identify relevant scenarios for our artifact, strengthened by applied case study research; and drawing from the scientific knowledge base to ensure usability of the artifact. Thereby, we ensure rigor and relevance of this research within the field of pharmaceutical supply chains. We identified users´ needs and analyzed their incentive structures to share information. Based on this analysis, we developed a conceptual approach by founding the artifact on the knowledge base. This approach provides evidence on how supply chain partners can realize mutual information sharing, process efficiency (Vinjumur, Becker, Ferdous, Galatas, & Makedon, 2010) or an increase in quality (Wu, Kuo, & Liu, 2005) by applying a de-central approach.

Applying scientific knowledge by developing artifacts, allows us to refine our knowledge on how specific antecedents on information sharing such as supply chain knowledge, information sharing, or information management capabilities need to be applied to satisfy business needs.

Further, our results enhance the scientific knowledge base by making additions to models, constructs, or guidelines.

2.4 Publications included in the Dissertation

Table 1 provides an overview of publications included in the dissertation. In addition, it provides information on the publication outlet, its ranking[2], and the status of the publication.

Pub No	RQ	Authors	Title	Year	Outlet	Ranking
1	RQ1	Suparna Goswami, Tobias Engel, Helmut Krcmar	A Comparative Analysis of Information Visibility in Two Supply Chain Management Information Systems	2013	Journal of Enterprise Information Management	C-Journal*
2	RQ2	Tobias Engel, Olga Birth, Suparna Goswami, Helmut Krcmar	How Supply Chain Governance Influences Information Sharing Behaviors: A Multiple Case Study Approach	2013	European Conference on Information Systems (ECIS)	B-Conf.*
3	RQ2	Tobias Engel, Oleksandr Sadovskyi, Markus Böhm, Helmut Krcmar	Interdependencies between antecedents on information sharing in supply chains: A concept-centric literature review	2nd round: revise and resubmit	International Journal of Physical Distribution & Logistics Management	B-Journal*
4	RQ3	Tobias Engel, Suparna Goswami	Variances in Supply Chain Information Sharing: An Analysis based on Incentive Alignment and Game Theory	2013	18th Annual SAP Academic Conference EMEA	NR
5	RQ3	Tobias Engel, Suparna Goswami, Markus Böhm, Helmut Krcmar	Enabling mutual information sharing in supply chains: An explanation on how antecedents influence information sharing behavior	Work in Progress	Journal of Business Logistics	B-Journal*
6	RQ4	Tobias Engel, Adrian Brugger, Suparna Goswami, Markus Böhm, Helmut Krcmar	Interdependent Determinants of Supply Chain Information Sharing: Evidence from the Tobacco Industry	2014	Academy of Management (AOM) Proceedings	Rank 1B: Premium Conferences +
7	RQ5	Tobias Engel, Manoj Bhat, Vasudhara Venkatesh, Suparna Goswami, Helmut Krcmar	An Ontology-based Platform to Collaboratively Manage Supply Chains	2014	Production and Operations Management Conference (POMS)	NR
8	RQ5	Tobias Engel, Suparna Goswami, Andreas Englschalk, Helmut Krcmar	CostRFID: Design and evaluation of a cost estimation method and tool for rfid integration projects	2014	Book chapter: In I. Lee (Ed.), RFID Technology Integration for Business Performance Improvement	NR
9	RQ5	Tobias Engel, Sascha Lunow, Julian Fischer, Felix Köbler, Suparna Goswami, Helmut Krcmar	Value Creation in Pharmaceutical Supply Chains using Customer-Centric RFID Applications	2012	Smart SysTech 2012, European Conference on Smart Objects, Systems and Technologies (Published in IEEE Xplore Library)	NR
10	RQ5	Tobias Engel, Andreas Englschalk, Nurettin Güner, Suparna Goswami, Helmut Krcmar	Investigating Information Sharing Behavior in Supply Chains: Evidences from an Embedded Single Case Study	2014	Hawaii International Conference on System Sciences (HICSS)	C-Conf.*

Table 1 – List of publications included in the dissertation

[2] Ranking: * Based on VHB-Jourqual 2.1; + Based on NUS IS Conference Ranking; NR: Not Ranked.

We answer the first research question by developing dimensions that form the base to evaluate different supply chain information systems in terms of their ability to support information sharing in supply chains. Therefore, we draw from information systems (DeLone & McLean, 1992; Miller, 1996) and supply chain literature (Closs, Goldsby, & Clinton, 1997; G. Q. Huang, Lau, & Mak, 2003) to develop the information sharing dimensions: variety of information, quality of information and connectivity. This analysis allows us to understand how various information systems allow firms to exchange information, improve our understanding for the quality of shared information, and support our understanding within the area of information management capabilities, especially from a technical perspective.

With the *first publication*, we gained insights on information sharing from a technical perspective. However, previous research identified further antecedents on information sharing such as trust, culture, bargaining power, or contracts (Fawcett et al., 2008a; Kampstra et al., 2006; Patnayakuni et al., 2006). Despite that, identified antecedents with similar attributes are named differently showing that there is no rich theoretical grounding for antecedents on information sharing (Ellram & Cooper, 2014). Therefore, in our *second publication*, we use previous findings to develop a semi-structured questionnaire and explore antecedents on information sharing on our own to gain in-depth and rich insights by using case study research (Yin, 2009). In addition, we conducted a literature review (Webster & Watson, 2002) to broaden our understanding of antecedents on information sharing, to identify inter-relations between antecedents, and to obtain an overview of used theories to analyze antecedents on information sharing (*third publication*).

Our case study findings verify the importance of information management capabilities for connecting supply chain information systems. We further found that supply chain knowledge is of high importance to realize supply chain performance, while bargaining power enables firms to initiate information sharing projects and to define rules for sharing information. The findings from our literature analysis provide evidence, that information sharing and its antecedents have been analyzed either from a single perspective such as limiting the research focus on one or two antecedents, with a focus on information sharing and not on antecedents, or with contradicting results. For example, asymmetric dependency is perceived as less productive and less stable than symmetric dependency (Ha & Shilu, 2008), while Klein and Rai (2009) argue that dependency from a buyers´ side increases the level of strategic information sharing among supply chain partners. Hence, previous research misses to relate antecedents with each other and to evaluate the importance of different antecedents for information sharing, although supply chains are considered as complex constructs influenced by various antecedents (Goswami, Ravichandran, Teo, & Krcmar, 2011; Hernndez-Espallardo, Rodriguez-Orejuela, & Sanchez-Perez, 2010; H. L. Lee, 2002).

Therefore, we incorporated our findings to develop a matrix that helps to explain the reasons for a shift in the level of exchanged information. By analyzing previous findings and reviewing literature, we found that researchers analyzed (the antecedents on) information sharing either from an operational perspective or with a focus on information sharing itself, not considering inter-dependencies between antecedents on information sharing; therefore using relevant theories such as the transaction cost economics theory (Ellram & Cooper, 2014; Straub et al., 2004). While this approach is appropriate to explain problems either from a technical perspective or from a cost perspective, it fails to analyze information sharing from a strategic perspective. More specifically, we learned from our case study research that bargaining power enables information sharing or defects information sharing in supply chains.

Within the *fourth publication*, we propose the matrix to organize antecedents on information sharing for each form of information sharing. The evaluation of the matrix provides evidence that the importance of antecedents on information sharing in supply chains can be categorized by using the proposed matrix (*fifth publication*). Further, we demonstrated how the identified antecedents influence information sharing by using expert interviews and positivistic case studies. For example, if firms have a trustworthy relationship, contracts reduce the level of information sharing as this creates mistrust at the partners´ side. In consequence, we elaborate on the reasons that lead to a shift of the level of information sharing.

Based on explored and identified antecedents, we developed our research model (*sixth publication*). The research model reflects inter-relations between presented antecedents and their impact on information sharing. The inter-relations were modeled by developing hypotheses and tested through conducting an explanatory case study. Our results provide evidence for inter-relations between the chosen antecedents. For example, we found that supply chain knowledge is more important than trust to achieve the highest supply chain performance, while trust fosters collaborative building of supply chain knowledge. Next, we apply specific findings for some industries and domains within the field of supply chain management in three consecutive steps to develop information sharing guidelines. To ensure the helpfulness of the information sharing guidelines, we conduct an additional case study.

In the *first* step, we propose on how to apply supply chain knowledge using an ontology (*seventh publication*). An ontology is of importance for information sharing in supply chains as it helps to exchange supply chain knowledge across supply chain partners. We use a platform to operationalize the exchange of information. Thereby, the ontology classifies the exchanged information into supply chain, context, and logistics. For example, the classification allows practitioners to exchange and use supply chain specific knowledge to compare forecasts with existing production plans or Key-Performance Indicators (KPIs).

From a technical perspective, the platform is based on Web 2.0 technologies enhancing partners to exchange and enrich supply chain knowledge. Further, partners can access the same information at the same time, reducing asynchronous information. For example, we provide practitioners with an editor to plan and visualize supply chains within a browser. Further, the editor allows partners to collaborate interactively on the same supply chain. In addition, we enrich the platform with a simulation engine and a calculation model. This functionality allows partners to run “what-if” analysis based on the calculation model and an agreed business logic (such as first-in, first-out). Hence, all supply chain partners have the ability to follow on changes or review the supply chain performance. Thereby, the platform supports the perception of changes and requirements among supply chain partners by visualizing the supply chain, and provide a base for the exchange of (specific) supply chain knowledge. In consequence, we provide evidence on how supply chain know-ledge and supply chain specific information needs to be shared to realize supply chain performance.

In a *second* step, we analyze what kind of information management capabilities are needed to implement RFID technology among supply chain partners. In addition, we identify relevant interfaces between information systems in order to ensure connectivity (*eighth publication*). Based on our findings, we develop a tool that contributes to a better understanding of cost drivers and business processes influencing the connectivity between supply chain information systems. The tool includes technical and functional elements of a RFID system and its cross-functional requirements. Based on a flexible structure, firms can conceptualize internal and inter-organizational settings and requirements.

Hence, the tool can be used to integrate all relevant supply chain partners in order to identify, to estimate, and to monitor all costs relevant to connect identified information systems. Thus, we contribute to information management capabilities of firms in the context of RFID systems. Further, we contribute to theory by proposing a new cost calculation method that covers all sorts of business processes and allows supply chain partners to estimate the costs of RFID integration projects. Moreover, practical implications include a more accurate estimation of the cost for integrating RFID system into the existing IT-landscape, and therefore, a risk reduction for RFID projects.

In the *third* step, we analyze how consumers (here: patients) have to be integrated to realize mutual information sharing such as sharing forecasts among supply chain members by using Near-Field-Communication (NFC) technology, as sub-class of RFID (*ninth publication*). By analyzing supply chain processes with focus on order management, customer relationship management, and inventory management, we propose a concept for information sharing among supply chain partners. The concept combines interactive non-stationary decentralized NFC services and stationary local information systems as solution for information sharing in pharmaceutical supply chains. The concept proposes to apply RFID tags for each drug package and NFC mobile devices at the consumers´ side (here: patients´ side) to read and write information on the RFID tag. To ensure availability of information at the doctors´ and pharmacists´ side, the concept allows members to synchronize information between the stationary and mobile system.

In consequence, partners can share information in both directions. This allows pharmacists to realize real-time order planning processes, avoiding stock-out situations, or other service functions such as individual intake information and schedules at the patients´ side. Our findings provide evidence for novel use-cases based on NFC and RFID. Further, our concept enables mutual information sharing among supply chain partners in the downstream supply chain. In consequence, we provide evidence on how connectivity of systems and (supply chain) knowledge management enhance pharmacists to optimize their processes, and offer new services for patients. Further, applying RFID technology allows supply chain partners to improve data quality and availability, combined with a central supply chain information system to plan, steer, and manage material flows and information flows.

While the seventh, eighth, and ninth publication apply supply chain knowledge and information management capabilities as relevant antecedents on information sharing, in a final step (*tenth publication*), we synthesize our findings and develop information sharing guidelines for supply chains. In particular, we use our improved understanding of the importance of the antecedents, their inter-relations, and their impact on information sharing to derive the guidelines. Further, we incorporate our learnings from applying the findings in specific contexts, and ensure the helpfulness of the guidelines by conducting an additional case study within the aircraft industry. In consequence, firms can use the supply chain information sharing guidelines to manage and improve their information sharing behavior, and mutually create supply chain performance. Figure 1 provides an overview of the publications.

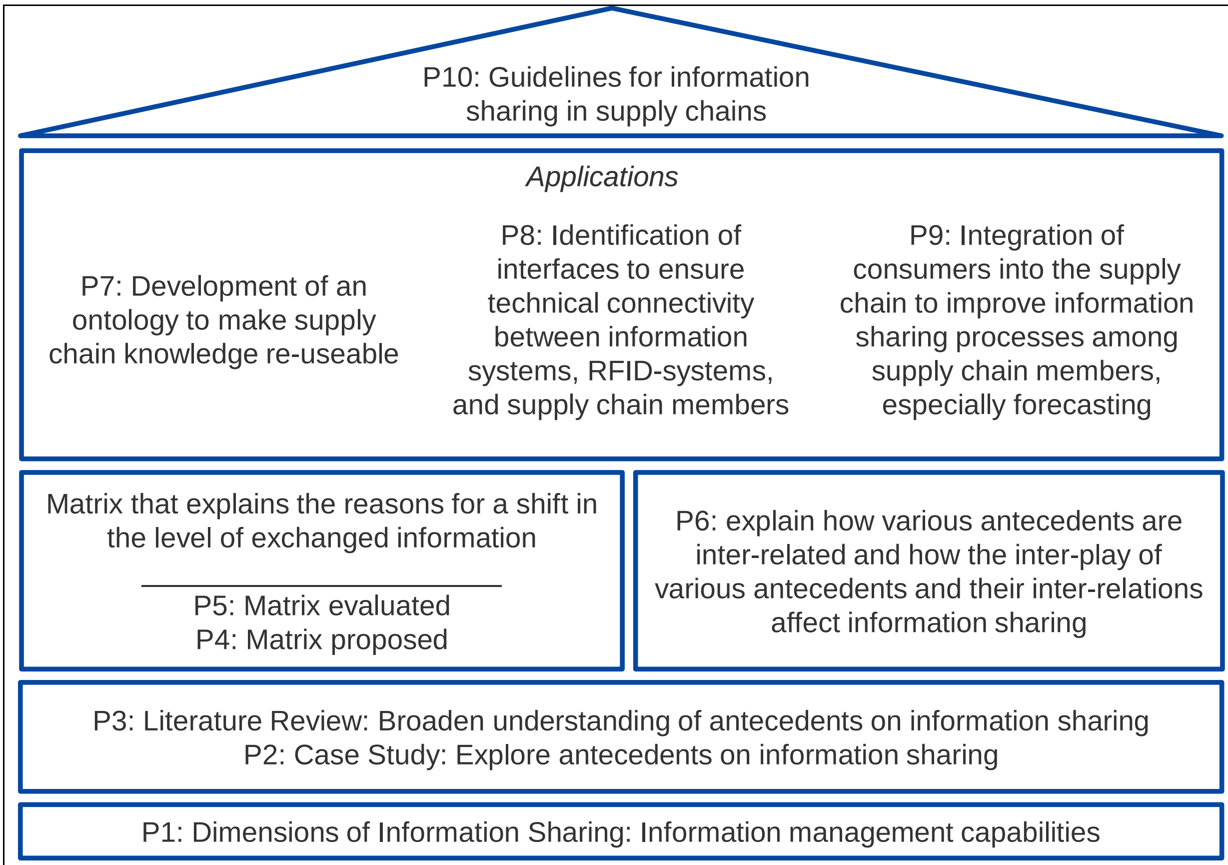

Figure 1 – Overview of Publications

Own illustration

2.5 Remarks on Format

The formatting styles of the eight publications and two submissions were different from one another. To apply a uniform format and consistency throughout the thesis, the publications and submissions have been reformatted. This includes tables and figures.

Each major part (A and B) comprises its own structure with a unique numerical structure. Hence, the structure of the papers have not been changed to ensure readability of the papers. This includes the numbering of tables and figures, as well as the references for each paper. Therefore, figures and tables are not listed in the overarching structure. To ensure a uniform format, the style of the references has been adapted.

In addition, minor editorial revisions to the original publications and submission were also made in case of formatting issues or in case of obvious mistakes such as spelling errors.

3 Theoretical Background

3.1 Theories on Information Sharing

Within this section, relevant theories related to supply chain management and information sharing are introduced and their relation to information sharing is presented. Thereby, game theory is explained more in detail, as it forms the core of the information sharing matrix, which is used to structure and organize the antecedents (Publication 4 and 5). In contrast, the other theories are only used to identify relevant antecedents on information sharing to build the research model for the explanatory case study, and to develop a more comprehensive coding scheme for this study (Publication 6), in contrast to the first explorative case study (Publication 2).

3.1.1 Agency Theory

The agency theory codifies social interaction between an agent and a principal by using contracts as unit of analysis. In specific, two problems are analyzed: the agency´s problem and the principal´s problem. The agency´s problem describes a state of contrary desires (or goals) between the principal and the agent, or the case in which the principal aims to verify the agent´s doing. The principal´s problem is to analyze different attitudes, behaviors, and preferred actions towards risk sharing between the agent and the principal (Eisenhardt, 1989a). Examples are universal such as contractual arrangements between employer and employee.

As the theory separates ownership and control of economic activities between an agent and a principal (Halldorsson, Kotzab, Mikkola, & Skjøtt-Larsen, 2007), the analysis between the principal and the agent can be applied in situations where the agent can make decisions affecting the principal, or in case the agent can decide on behalf of the principal (Ross, 1973). Within the supply chain context, an agent can be considered as the stronger supply chain partner, while the weaker partner is considered as principal. In consequence, the principal-agent theory can be used to reflect supplier-buyer relationships in supply chains (Voigt & Inderfurth, 2012).

While the theory emphasizes on the asymmetry of relationships and allows researchers to study factors such as management support, incentive alignment, governance, or quality of shared information, the possibilities for applying the agency theory among supply chain with more than two nodes are limited. Further, the agency theory mostly analyzes internal antecedents on information sharing such as how managerial incentives structures contribute to supply chain integration (J. Kim & Mahoney, 2005; Villena et al., 2009).

3.1.2 Transaction Cost Theory

Transaction cost theory studies economic situation adapting a contractual perspective. Hence, transaction cost economics analyzes economic situations on a micro-analytic level, thereby focusing on the importance of asset specificity and contracts; treating different (social) behaviors as unimportant (Williamson, 1989). Further, transaction cost theory helps to identify transaction costs such as search and information costs, bargaining and decision costs, and policing, and enforcement costs in economic exchange situation (Dahlman, 1979; Williamson, 1989). In consequence, the transaction cost theory aims for achieving efficiency (J. Kim & Mahoney, 2005; Williamson, 1989).

Applying transaction cost theory within the field of supply chain management focuses on the decision whether to outsource activities or produce products in-house. This decision process evaluates asset specificity, includes behavioral assumptions of bounded rationality, and considers risks such as opportunistic behavior. Therefore, various costs such as opportunism, contract penalties, long-term relationships, or joint investments of an exchange are included in the decision process (Halldorsson et al., 2007; Jraisat et al., 2013; Subramani, 2004).

However, from a supply chain perspective, transaction cost theory does not consider relational aspects, especially social antecedents (Dahlman, 1979; Jraisat et al., 2013). Therefore, transaction cost economics does not consider basic requirements and the nature of supply chains and networks (Jraisat et al., 2013). Hence, analyzing supply chain relations requires researchers to compliment transaction cost theory with other theories in order to reflect intra- and inter-organizational dependencies and ensure a comprehensive analysis of involved antecedents.

3.1.3 Resource-based View

The resource-based view focuses on internal strength of a firm by applying a combination of tangible and intangible resources and capabilities which are scarce, durable, and hard to imitate (Amit & Schoemaker, 1993; Wernerfelt, 1984). Thereby, resources and capabilities are seen as strategic assets (Amit & Schoemaker, 1993). In consequence, the resource-based view emphasizes on gaining sustainable competitive advantage for a firm (Agan, 2012) by creating heterogeneous and not mobile resources (Barney, 1991). As a combined usage of the resource-based view and transaction cost theory allows researchers to incorporate relationship-specific assets, both theories can be seen as complementary (Subramani, 2004).

Due to its internal focus on firms´ competitive advantage (derived from resources and capabilities), the resource-based view has been used to describe and analyze the sources of competitive advantage (Halldorsson et al., 2007). Further, the resource-based view has been used to analyze complementary interactions between firms using inter-organizational information systems (S. M. Kim & Mahoney, 2006). Moreover, the resource-based view can be applied to analyze influences on factors contributing to the competitive advantage of a firm by developing unique competencies or new heterogeneous resources such as technical competencies, reputational resources (such as trust), and organizational resources (such as leadership or cultural resources) (Amit & Schoemaker, 1993).

However, the major drawback of the resource-based view is that it only considers resources and capabilities from a firm´s perspective, not considering relationships in order to collaborate. Therefore, using resource-based view would limit the analysis of antecedents on information sharing to an egoistical perspective of a single supply chain member; without emphasizing to create mutual benefits for all supply chain partners.

3.1.4 Social and Socio-political Theories

Social and socio-political theories abstract economic aspects and include social interactions by incorporating factors such as trust or relationship commitment, arguing that, for example, transaction cost theory underestimates the role of social interactions (Zhao, Huo, Flynn, & Yeung, 2008). Hence, social theories analyze how behavior is affected by social relations (Granovetter, 1985). Further, social theories suggest that not only economic factors but also social factors are of importance to analyze relationships (Zhao et al., 2008). For example, Ke and Wei (2005) state that transaction cost theory is not sufficient to understand what affects firms' decision to enter into a supply chain relationship and share information or not. As for this thesis, the social exchange, social network, and social capital theory are the most important ones.

The *social exchange theory* describes the exchange of resources in trustworthy relationships based on shared value and in absence of controls against opportunism (Zhao et al., 2008). For example, analyzed constructs include satisfaction, reputation, or handling of conflicts and its effect on trust (Kwon & Suh, 2004). The *social capital theory* helps to understand norms and social relations that facilitate certain actions of individuals (Coleman, 1988) or from a network perspective (Narayan & Cassidy, 2001). In consequence, social capital theory can be used to analyze facilitation of benefits from an individual or network perspective (Coleman, 1988; White, 2002) by considering social capital dimensions such as trust, norms, or group characteristics (Narayan & Cassidy, 2001). For example, W. Tsai and Ghoshal (1998) analyze value creation in networks using a structural, relational, and cognitive dimension. The *social network theory* allows researchers to visualize supply chain relationships using a quantitative setting to identify various factors such as power dependencies, contractual agreements, or key actors (Y. Kim, Choi, Yan, & Dooley, 2011). Further, the theory allows researchers to analyze complex relationships in supply networks by combining data from individuals and groups (Borgatti & Li, 2009). The theory describes and maps activities of actors and resources to model interdependencies and relationships between supply chain partners (Halldorsson et al., 2007).

In consequence, social theories analyze intangible or unquantifiable antecedents of firms and occurring phenomenon during economic activities. Researchers applying the social capital theory within the field of supply chain management often use factors such as trust, interdependence, relationship and commitment, and organizational culture. Although it has been recognized, that supply chains have hard aspects such as transaction costs and soft aspects such as employees or trust (Borgatti & Li, 2009), the described theories either focus on dyadic relationships or have limited behavioral assumptions (see Table 2).

Characteristics	Agency Theory	Transaction Cost Theory	Resource-based view	Social theories
Behavioral assumptions	Bounded rationality; asymmetric information; goal conflicts	Bounded rationality; Opportunism	Bounded rationality; Trust	Bounded rationality; Trust
Problem orientation	Contract design	Efficient governance structure	Internal competence development	Dyadic relationships embedded in networks

Time dimension	Static	Static	Static/dynamic	Dynamic
Primary focus	Contracts and incentives	Transaction attributes (e.g. asset specificity)	Resource attributes	Inter-firm relations
Function of relationship	Efficient division of labor	Market failures	Access to complementary resources	Access to heterogeneous resources
Primary domain of interest	Alignment of incentives in dyads	Exchange and transaction	Production and firm resources/capabilities	Exchange and adaption processes

Table 2 – Comparison of theories

Adapted from: Halldorsson et al. (2007)

Therefore, analyzing antecedents on information sharing within the field of supply chain management needs an appropriate research method that allows researchers to visualize and transcribe hard and soft aspects/facts, and to combine both in order to create valuable insights. As stated in section 2.1, we believe that using a qualitative approach towards analyzing supply chain behavior by adapting basic game theoretical concepts is feasible for understanding the antecedents on information sharing.

3.1.5 Game theory

Game theory allows researchers to analyze decisions underlying the basic assumption of rationality and taking expectations of others into account (Osborne & Rubinstein, 1999). For example, game theory allows researchers to explain and analyze aspects of inter-organizational behavior such as cooperation within strategic alliances (Parkhe, 1993a, 1993b). Thereby, real scenarios can be modeled in a game and explain occurring phenomenon (Osborne & Rubinstein, 1999). A game describes possible interactions between players without specifying the actions that players do take. Thereby, a systematic description of the outcomes represents the solution. Games can be clustered into strategic games, extensive games with and without perfect information, and coalitional games. While strategic and extensive games can be clustered into non-cooperative games, coalitional games are termed cooperative games. Non-cooperative games represent individual players and cooperative games represent joint actions of players (Osborne & Rubinstein, 1999).

Strategic games force all players to make their choices once and at the same time, while extensive games allow players to consider their choices at the beginning of the game but also whenever a player has to make a decision. Further, games with perfect information represent players being knowledgeable about all facts while imperfect information games represent the opposite. As coalitional games represent joint actions (also termed as group or coalition actions), it specifies the coalition that takes the joint action. Furthermore, coalitional games consider the profile of the players' preferences over the set of all possible outcomes, and thereby represent individuals' preferences (Osborne & Rubinstein, 1999). In consequence, game theory allows researchers to study antecedents on information sharing in supply chains using the simplest form of game theory, the prisoners´ dilemma game (Parkhe, 1993b; Straub et al., 2004).

The prisoners' dilemma game explains why two individuals might not cooperate even if it is in their best interest: Each player has two choices allowing each player to choose out of four strategies that are mutual cooperation (MC), unilateral cooperation (UC), unilateral defect (UD) and mutual defect (MD). The preference of each player is UD > MC > MD > UC. However, the highest payoff can be obtained through mutual cooperation (Nash, 1950; Parkhe, 1993b). As firms may focus on increasing (unilateral defect) their own profits instead of choosing to collaborate (mutual cooperation), different information sharing behaviors will appear (Argyres & Liebeskind, 1999; Fawcett et al., 2012; Nair et al., 2011).

From an information sharing perspective, we can differentiate between three forms of information sharing: mutual information sharing (equivalent to MC), unilateral information sharing (equivalent to UD and UC), and no information sharing (equivalent to MD). Mutual information sharing is the most preferable choice from the supply chain perspective since it allows upstream and downstream partners to improve their business processes. However, unilateral information sharing is the most preferable choice, if one partner aims to realize a local optimum. Further, no information sharing results in the lowest firm and supply chain performance.

3.2 Antecedents on Information Sharing

In the following, a short introduction to information sharing is given, followed by an explanation of the relevant antecedents on information sharing for this thesis, as incorporated in our research model. Hence, based on existing and acquired data, the research model represents the most relevant antecedents on information sharing: bargaining power, contracts, trust, information management capabilities, and supply chain knowledge.

3.2.1 Information Sharing

Previous literature has acknowledged the important role of information sharing for managing supply chains (H. L. Lee et al., 1997, 2004). Thereby, strategic and operational information sharing can be considered as more important to improve supply chain processes than transactional information sharing. While transactional information sharing is necessary to manage the exchange of goods, operational and strategic information sharing allows firms to realize additional gains and thereby improve their performance (Seidmann & Sundararajan, 1997). Moreover, additional rents can be generated by strategic information sharing such as margins (Gérard P. Cachon & Swinney, 2011; Klein & Rai, 2009). Sharing margin structures enhance firms to calculate risks mutually. This allows supply chain partners to avoid the calculation of safety costs two times, and strengthens competitiveness of the supply chain. Further, in order to realize additional gains, it is of importance to share relevant, timely, and accurate information. In addition, supply chain partners need to have the knowledge and capabilities to handle shared information appropriately in order to improve their supply chain performance (Goswami, Ravichandran, Teo, & Krcmar, 2012; E. T. G. Wang & Wei, 2007).

However, information sharing behavior varies and many firms avoid to share operational and/or strategic information despite the potential for higher profits (Prokesch, 2010). This avoidance of mutual information sharing and willingness of firms can be constituted by strategic considerations such as fear of opportunistic behavior, missing (technical) capabilities, or supply chain knowledge (Fawcett, Osterhaus, Magnan, Brau, & McCarter, 2007; H. L. Lee et al., 1997; Parkhe, 1993b). More specifically, if firms perceive that supply chain partners make use of information asymmetries to increase monetary gains (e.g. to realize higher margins than agreed upon), firms will safeguard by restricting information sharing to a transactional level. This scenario is given in opportunistic and/or purely transactional relationships (Argyres & Liebeskind, 1999; Nair et al., 2011).

In practice, many firms either purposefully avoid information sharing or are not capable of varying the factors the influence information sharing (Prokesch, 2010). For example, isolated specific behavior of firms often results in a tit-for-tat strategy causing lower rents (Axelrod, 1984). Firms experiencing operational inefficiencies often establish several actions such as information sharing and contractual safeguards to counter such behavior (Mason-Jones & Towill, 1997). Furthermore, even though firms agree on mutual information sharing, missing capabilities and knowledge results in a lower level of information sharing (Bailey & Francis, 2008).

3.2.2 Bargaining Power

Bargaining power allows a firm to exert influence over a partner. Therefore, the effect of bargaining power on information sharing has been analyzed in various settings such as supply chain specific investments (Nair et al., 2011) or the behavior in supply chains with exit options (Berstein & Federgruen, 2005). Further analysis included games with cooperative and non-cooperative behaviors (Esmaeili, Aryanezhad, & Zeephongsekul, 2009) and the usage on how contractual safeguards (inventory policies) minimize supply chain costs (Gérard P. Cachon & Zipkin, 1999). Moreover, the influence of contracts on information sharing and their effect on information sharing processes such as sharing of forecasts has been analyzed (Gérard P. Cachon & Lariviere, 2001a).

While the general willingness of firms to share information with supply chain partners can be realistically assumed, the absence of trust in supply chain relationships hinders the exchange of information (Fawcett et al., 2006). Further, information is often tightly controlled as a resource of power resulting in a unilateral focus of firms´ on own profits (Argyres & Liebeskind, 1999; Nair et al., 2011). Therefore, the form of power – reward power, coercive power, expert power, referent power and legitimate power – in relation to information sharing needs has to be considered (French & Raven, 1959). Depending on the form of power, it has to be analyzed how and for what reason bargaining power is used, and how it contributes to information sharing. Examples are contractual punishment or reward agreements (Maloni & Benton, 2000) or expert power to introduce new systems and methods such as the SCOR model (W. Y. C. Wang, Chan, & Pauleen, 2010).

3.2.3 Contracts

The use of contracts enhances firms to guide partners´ activities towards aimed objectives (Goo et al., 2009). Thereby, formal and informal contracts create a safe relational basis for partners (Poppo & Zenger, 2002). Further, a contract provides mechanisms such as reward or penalty systems to ensure collaboration acting as incentive for involved supply chain members. Accordingly, a contract can safeguard supply chain specific investments (Gérard P. Cachon & Lariviere, 2005; Williamson, 1989), ensure cooperative behavior, lower the risk of suffering from opportunistic behavior from the partner (either supplier or buyer), and losing strategic valuable information (Klein & Rai, 2009).

Previous research found that contracts act as enabler for information sharing by reducing opportunistic behavior and formalizing responsibilities, even though the relationship can be labeled as trustworthy (Ghosh & Fedorowicz, 2008). Furthermore, it has been found that markets with high competition stimulate supply chain partners to collaborate, share information, and make performance-enhancing investments (Liker & Wu, 2000), in case partners have a long-term orientation and show commitment (Gérard P. Cachon & Lariviere, 2005). Moreover, the effect of relational characteristics on contractual factors has been analyzed for specific information technology (IT) systems and in the field of IT outsourcing (Goo et al., 2009; S. M. Kim & Mahoney, 2006; Rai, Keil, et al., 2012). However, the results cannot be easily adopted for information sharing in supply chain relationships (Van der Vaart & van Donk, 2008), as further (relational) mechanisms such as capabilities or supply chain knowledge are of importance. Further, their role and inter-dependencies with other antecedents needs to be regarded in specific supply chain settings (Rai, Keil, et al., 2012).

3.2.4 Trust

Trust defines the willingness of a firm to be vulnerable to the actions of a partner, irrespective of the ability to control that action (R. C. Mayer, Davis, & Schoorman, 1995). While trust is based on fair behavior and a sense of reciprocity, this does not imply that (economic) outcomes will be equally divided (Hart & Saunders, 1997). Furthermore, the importance of trust for information sharing in supply chains increases by the number of supply chain members. The importance amplifies in case decisions have to be made with incomplete information (Komiak & Benbasat, 2004). In addition, trust can substitute contracts (Rai, Keil, et al., 2012) and increase efficiency of problem solving, realize better communication among the partners , and result in operational and strategic information sharing (Fawcett et al., 2012).

As trust strengthens supply chain relationships, it motivates firms to invest idiosyncratically into relationship-specific assets in order to form long-term relationships (Doney & Cannon, 1997). Hence, trust reduces opportunistic behavior, uncertainty, risks (Alvarez, Barney, & Douglas, 2003), and fosters satisfactions (Zaheer, McEvily, & Perrone, 1998). Thereby, trust fosters the reduction of complexity by eliminating dispensable processes such as the justification of decisions (Kramer, 1999). In consequence, supply chain relationships that are built on trust can be characterized by shared values, behaviors and policies (Morgan & Hunt, 1994). Further, trustworthy relationships are characterized by participation and involvement of partners in joint decision making and setting mutual (commercial) goals contributing to a successful partnership (Dwyer & Oh, 1988). However, the joint influence of trust, contractual factors, and further antecedents remain relatively unexplored (Rai, Keil, et al., 2012).

3.2.5 Information Management Capabilities

Information management capabilities represent internal capabilities of firms (Mata, Fuerst, & Barney, 1995) emphasizing firm´s ability to implement IT-based resources in co-presence with other resources and capabilities (Bharadwaj, 2000). Information management capabilities, especially technical capabilities, play a significant role for connecting inter-organizational information systems; thereby contributing to supply chain performance (K. J. Mayer & Salomon, 2006). In addition, only technical information management capabilities are not sufficient to realize information sharing in supply chains (Fawcett et al., 2007), as, for example, to materialize on investments in information technology, further information management capabilities are required.

Previous findings show that firms outsource activities in the presence of weak capabilities, and use contracts to safeguard against miscellaneous hazards (K. J. Mayer & Salomon, 2006). As these findings explain the avoidance of information sharing with uniqueness of capabilities (K. J. Mayer & Salomon, 2006), a more nuanced understanding of information management capabilities on information sharing, and their relation to further antecedents such as learning and supply chain knowledge is needed as firms handle information sharing differently (Mithas et al., 2011; Rai, Keil, et al., 2012).

3.2.6 Supply chain knowledge

Kang, Mahoney, and Tan (2009) show the importance of knowledge management and learning. Further, knowledge management is of importance to realize efficient collaboration among supply chain partners. Supply chain knowledge represents domain specific knowledge that allows firms to integrate supply chain processes and improve supply chain collaboration by capturing, sharing, and contributing continuously to this specific supply chain knowledge base (Combs & Ketchen, 1999). As specific knowledge is often tacit and costly, it flows more easily within firms than between them (Combs & Ketchen, 1999; Darr, Argote, & Epple, 1995).

Despite that, supply chains require inter-firm collaboration and the exchange of supply chain knowledge, we analyze how firms share specific knowledge to improve supply chain processes (Combs & Ketchen, 1999). For example, supply chain knowledge allows firms and their employees to identify, manage, and share relevant information with partners (Goswami et al., 2012; Hult et al., 2004). This allows firms to influence supply chain performance positively by optimizing processes such as distribution of goods, by improving the efficiency of production planning processes, or by shortening cycles times (Goswami et al., 2012; Hult et al., 2004). Furthermore, supply chain knowledge enables firms to provide customers with customized services such as alert notifications (Kiely & Armistead, 2004), leading to competence trust among partners and creation of inimitable resources.

However, as previous research findings are ambivalent (Combs & Ketchen, 1999; Marra, Ho, & Edwards, 2012), and, in practice, firms cope with organizational silos and lack information visibility (transparency) due to missing information (Marchese & Paramasivam, 2013), we integrate supply chain knowledge as own antecedent on supply chain information sharing.

4 Discussion

This chapter summarizes and discusses findings from the publications. Thereby, it will allow the reader to understand on how a game-theoretic perspective helps to explain the importance and influence of antecedents for information sharing in supply chains. Further, the discussion provides insights on how the antecedents are inter-related and their effect on information sharing behavior. In addition, the reader will learn how guidelines derived from applied findings can be used for the development of information sharing strategies. In consequence, this chapter summarizes and describes how the research objectives of this thesis and its sub-objectives are accomplished.

4.1 Summary of Findings

The *first research question* aims to derive appropriate dimensions for analyzing mechanisms of information sharing between supply chain partners in order to understand how intra-organizational information systems (here: supply chain information systems) contribute to sharing relevant and accurate, and timely information.

The dimensions are developed from theory covering variety of information, quality of information, and connectivity (of systems) (Goswami, Engel, & Krcmar, 2013). *Variety of information* characterizes all data that is directly related to supply and demand, and which can be shared with supply chain partners. This includes, for example, inventory levels, sales data, demand forecast, order status, product planning, logistics, and production schedules. Based on our analysis, we included master data, transactional data, demand information, inventory information, production information, transportation information, financial information, performance metrics, and alerts. Further distinctions within each characteristic were made. Using these characteristics allows partners to support decisions and achieve required information transparency along the supply chain (Closs et al., 1997). The second dimension, *quality of information*, includes accuracy, availability, compatibility, completeness, confidentiality, and timeliness. The identified characteristics meet the needs of firms (Rai et al., 2006), and ensures that information is relevant, of use for firms and supply chain partners, and meets quality requirements (English, 2001; Miller, 1996). While the first and second dimension focus on the information, the third dimension, *connectivity*, relates to the transfer of information between supply chain information systems. Connectivity of (information) systems allows information sharing on an intra- and inter-firm level. In addition, internet-based systems can promote information sharing and therefore offer potentials to improve connectivity (Bussiek, 1999) fostering usage of latest supply chain concepts such as Vendor Managed Inventory or Collaborative Planning Forecasting and Replenishment (Nambisan, 2000). During our research, we identified internal connectivity and external connectivity as attributes for this dimension. Thereby, internal connectivity refers to the exchange of information within the firms´ boundaries. In contrast, external connectivity allows researchers to analyze information sharing across the boundaries of firms; therefore ensuring a comprehensive analysis of the supply chain with customers, suppliers, 3rd party service providers and others (Closs et al., 1997).

Our research findings can be used to compare and analyze supply chain information systems on functional criteria, which allow firms to realize information sharing and thereby achieve transparency and information visibility within a supply chain. Furthermore, we contribute to recent supply chain literature with focus on information sharing and supply chain information systems by reviewing the role and dimensions of information sharing.

Further, as our dimensions distinguish characteristics of supply chain information systems, practitioners can use the dimensions to select the right system based on their supply chain strategy and the needs of the supply network. This is specifically of importance, as supply chains with multi-nodes have different requirements in comparison to dyadic relations (Steinfield, Markus, & Wigand, 2011). Moreover, choosing appropriate information systems enables firms to align their supply chain processes, and thereby support information sharing among supply chain partners.

The dimensions can be used to compare different supply chain information systems and analyze the role of information sharing in supply chain related decisions and outcomes. Further, developing the dimensions improves our understanding of information sharing processes (such as automatic transfer versus manual transfer) of supply chain information systems. Moreover, by developing the dimension, our paper allows scholars and firms to evaluate and assess information sharing behaviors from a technical perspective regardless of the used information system. Therefore, our findings allow us to explore antecedents on information sharing more in-depth, especially from an information management capabilities and supply chain knowledge perspective.

The *second research question* aims at exploring and classifying antecedents such as information management capabilities on information sharing in supply chains. As there is no clear understanding of the antecedents on information sharing from a theoretical perspective, and in practice, 90% of firms still avoid sharing operational and strategic information with their partners (Ellram & Cooper, 2014; Karen, 2010; H. L. Lee et al., 1997); therefore, we took a two-fold approach by conducting an explorative case study and reviewing the literature.

Within the explorative case study, we analyzed the antecedents on information sharing from an information management capabilities perspective, and considered further antecedents labeled as relational antecedents. Thereby, the information management capabilities were distinguished into technical and advanced capabilities. Using the information management capabilities allowed us to gain insights on how firms and their supply chain partners connect systems, and how data such as master data is managed. Further, we analyzed what kind of information is shared, how it is handled, and for what kind of purpose it is used. In addition, we gained insights on information sharing frequencies. The relational perspective enabled us to improve our understanding about the inter-play and inter-relations between bargaining power, trust, and length of the relationship.

Our findings confirm the importance of technical capabilities and the importance of inter-organizational information systems to enable information sharing in supply chains (Premkumar, 2000). Furthermore, we extend previous research by stating the importance of supply chain knowledge and its positive impact on efficient information sharing and supply chain performance. Moreover, we found that transactional information sharing is done on a daily base, while operational and strategic information depends on the relationship. In specific, the length of the relationship and the level of trust had a positive influence on information sharing. In addition, our findings were contrary on the effect of bargaining power on information sharing. Stronger buyers set rules for information sharing, while stronger suppliers did not set rules with their buyers. Further, one of the stronger buyers shared operational and strategic information, but refused to use information mutually. We interpreted these differences as missing supply chain knowledge or, in case of the stronger supplier, as expectations for future business (Heide & Miner, 1992). Furthermore, we found that bargaining power was used by one firm to initiate information sharing. Our findings contribute to a better understanding of antecedents on information sharing by showing the low importance of information management capabilities on the decision whether to share information or not, and provide evidence on the importance of trust, bargaining power, and supply chain knowledge.

For the literature review, we used a concept-centric approach (Webster & Watson, 2002). We analyzed relevant databases and identified 75 relevant publications (39 qualitative studies and 36 quantitative studies). Further, the identified antecedents were clustered into nine groups. The results provide evidence that only few research exists on analyzing and explaining interrelations of antecedents on information sharing and, in specific on the impact on information sharing. We found that trust, technical competence, and relationship and commitment are the most researched antecedents. In contrast, the influence of management support, governance, and overall costs of information sharing is not explored in detail. Overall, it can be said that quantitative and qualitative research has been found to be rather scarce, confirming that there is a need for rich and robust theoretical grounding (Chicksand, Watson, Walker, Radnor, & Johnston, 2012).

Most of the research analyzes the effect of antecedents on supply chain performance. While a positive effect of information sharing on supply chain performance has been found and verified, there is no explanation on why firms avoid sharing information. Further, our results allowed us to cluster antecedents (Publication 3) and provide first insights on their importance (Publication 2). However, we can state, that further research needs to identify an appropriate theoretical approach to organize the antecedents (based on their importance for information sharing), and to analyze on how antecedents affect shifts in information sharing in supply chain relationships.

As previous research has analyzed antecedents on information sharing using various theories (Carter et al., 2014), and there is still a rich theoretical grounding missing (Chicksand et al., 2012), we chose game theory as theory for our further research; as recommended by Straub et al. (2004). Thereby, with the *third research question*, we contribute to a new perspective on information sharing in supply chains. Further, by using the simplest form of game theory, the prisoners´ dilemma, we develop a matrix to organize antecedents on information sharing distinguishing three forms of information sharing: mutual information sharing, unilateral information sharing, and no information sharing (Seidmann & Sundararajan, 1997)[3].

We found that bargaining power could be used to initiate information sharing, while forcing upstream or downstream partners to share information either results in no information sharing or unilateral information sharing. In contrast, a mutual agreement on information sharing procedures provides a base for collaboration. Further, we found that, mutual agreements should be in form of written contracts. This allows partners to discuss, define, and describe procedures, even though the procedures do not have to be detailed. Based on our results, we can state that bargaining power and contracts are first steps towards mutual information sharing. Bargaining power initiates information sharing, while contracts enable further steps. Hence, to realize mutual information sharing, partners have to trust each other. Trust acts as adhesive and flexible tie, and helps to solve problems in a friendly environment. Therefore, trust aligns collaborative behavior and strengthens the relationship. However, partners have to invest in their information management capabilities and supply chain knowledge for achieving the highest level of information sharing. Thereby, information management capabilities help partners to ensure connectivity of systems and a high quality of shared date, and supply chain knowledge ensures appropriate handling and usage of shared information. In consequence, if partners have the awareness and capabilities to use and share relevant, timely, and appropriate information, then, partners will be able to realize the highest supply chain performance.

The matrix enhances researchers to explain (and practitioners to understand) the necessity of information sharing as the discrepancy between realizing the highest supply chain performance (by mutual information sharing) and having the highest risk to suffer from opportunistic behavior (in case of unilateral information sharing). Figure 2 provides an overview of our matrix visualizing inter-relations and inter-dependencies between antecedents on information sharing and their importance. In consequence, our results provide a possibility to relate previous research findings on antecedents on information sharing within one matrix. Further, our results complement research on dynamic effects on information sharing (Fawcett et al., 2012), and further contribute to theory by using a different theoretical perspective (game theory) to analyze antecedents on information sharing. In addition, as we evaluated the matrix using rich case study data, we contribute to breadth and depth of theory (Ellram & Cooper, 2014). From a practitioners´ side, our findings help firms to develop information sharing strategies for managing the exchange of information in supply chains. This allows firms to gain flexibility, and thereby ensure high competitiveness of the supply chain. However, a quantitative setting is needed to evaluate and strengthen findings on the inter-relations, and to generalize findings by hypothesizing and evaluating inter-dependencies between the antecedents. Hence, we conduct an explanatory case study using a research model with hypotheses.

[3] Transactional information sharing is necessary to coordinate and manage the exchange of goods, while sharing of operational information provides firms with the opportunity to realize more efficient supply chain processes (Angulo, Nachtmann, & Waller, 2004). Therefore, "no information sharing" refers to the avoidance of firms to share operational and strategic information excluding transactional information. Sharing of strategic information sharing allows firms to generate additional rents by exchanging proprietary information (Gérard P. Cachon & Swinney, 2011; Gavirneni, Kapuscinski, & Tayur, 1999). In addition, previous findings provide evidence that operational and strategic information sharing enables firms to improve their supply chain performance (H. L. Lee et al., 2004; Straub et al., 2004). See also section 3.3.1.

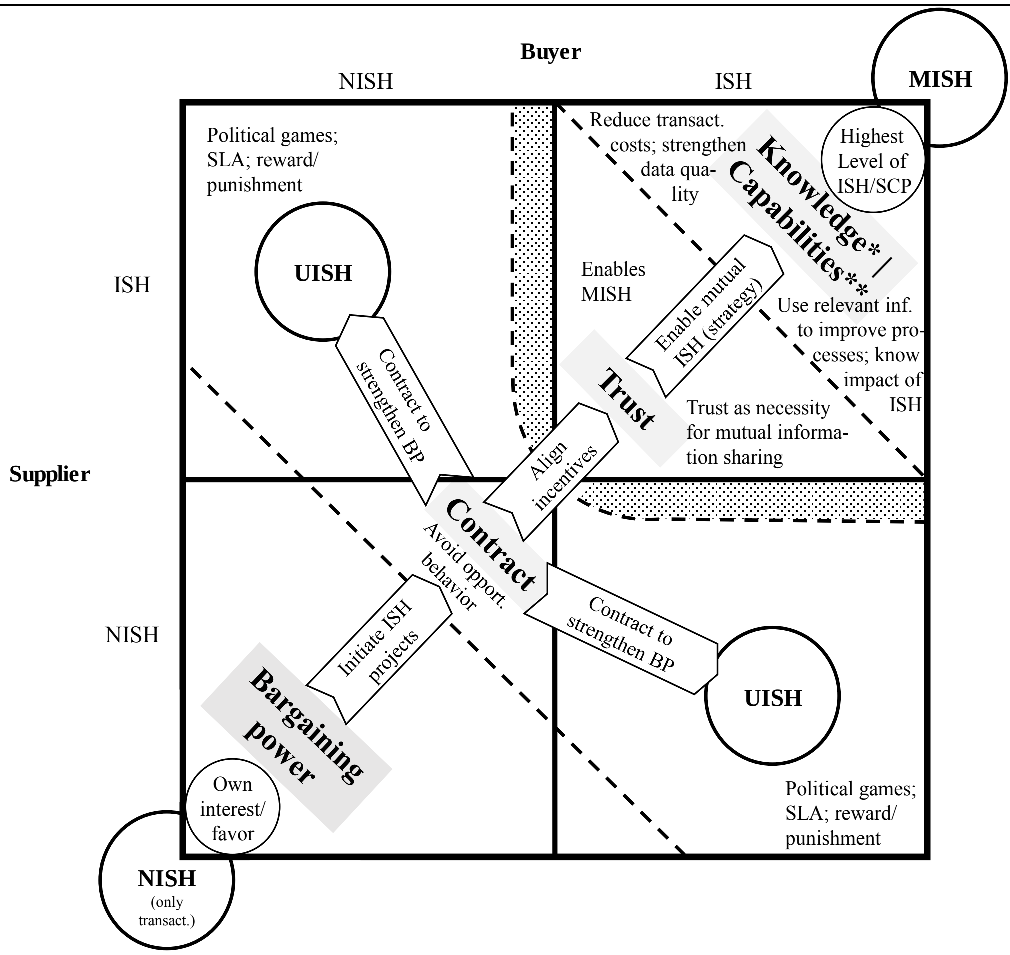

Figure 2 – Information Sharing Matrix

Own illustration; part of Publication 5 (see PART B)

Note: MISH: mutual information sharing; UISH: unilateral information sharing; NISH: no information sharing; ISH: information sharing; SLA: Service-level agreement; *Knowledge represents supply chain knowledge; ** Capabilities represent information management capabilities; SCP: Supply chain performance

As the findings from the third research question have to be strengthened, we developed a research model including hypotheses to generalize our findings on the inter-relations of the antecedents on information sharing (thereby addressing *research question four*). For the development of the research model, we draw from our previous findings (own findings and findings from published papers). We incorporated the following antecedents: contract, trust, bargaining power, and information management capabilities. While all antecedents are the same as presented in section 3.2, information management capabilities and supply chain knowledge are combined within the construct "information management capabilities"[4].

Our findings allowed us to verify and generalize on the inter-relations of antecedents, the importance of antecedents, and extend our knowledge allowing us to split information management capabilities into supply chain knowledge and information management capabilities. In

[4] The combination represents our knowledge on antecedents on information sharing at the time of the submission of Publication 6. We used our findings to revise the combination, and split the antecedent "information management capability" into information management capabilities and supply chain knowledge.

particular, we found that bargaining power is not important for information sharing, while contracts enable information sharing (projects) and trust allows partners to align their information sharing strategy. By following up on the case itself, we were able to verify that supply chain knowledge positively relates to the highest level of information sharing, thereby allowing firms to realize a higher supply chain performance. For example, the wholesaler was able to reduce his inventory by approximately one million Euro by simply making use of shared information in a different way.

Further research can generalize our research model by analyzing supply chains in different industries, adapt the model towards splitting supply chain knowledge and information management capabilities into two constructs, use quantitative research (such as surveys or experiments) to generalize the findings, or apply our findings by developing prototypes. This would allow researchers to develop information sharing guidelines. Hence, we address the *fifth research question* by developing three prototypes (Publication seven to nine) in order to derive information sharing guidelines (Publication ten).

In the *seventh publication*, we develop a prototype aiming to create, adapt, and steer collaboratively supply chains by applying supply chain knowledge. The paper relates to missing information within firms and among partners about existing material flows. Many firms plan supply chain from scratch and thereby miss to address possible synergy effects such as lower transportation costs per part, while material flows already exist. For example, firms ship materials from A to B using a “Less-Truck-Load” (LTL) carrier, while combining existing and planned material flows would allow firms to realize “Full-Truck-Loads” (FTL), thereby reducing the price per part. Therefore, we propose an ontology-based, knowledge-assisted platform to reuse domain knowledge captured in previous supply chain projects, and support simulation of various network configurations.

Our platform adapts the architecture from Bhat et al. (2013) and includes the following components: diagram editor, simulation engine, the calculation model, and the collaboration engine. The diagram editor provides the possibility to model supply chains in a web-based interface such as Mozilla Firefox. The simulation engine enhance firms to address supply chain specific constraints. Further, the calculation model calculates supply chain costs for each scenario. In addition, the collaboration engine contributes to supply chain collaboration by providing information to involved partners using Web 2.0 tools such as Wikis. Furthermore, all components are inter-connected, can inter-act, and are built as modules. Especially the modular setup of the platform allows users to add new components such as customized software to the platform. Further, all components are independent, can be (re-) configured, or replaced by other components such as custom simulation engines or calculation models.

Our research complements concepts of interoperability among heterogeneous software components from C.-C. Huang and Lin (2010) and Ye, Yang, Jiang, and Tong (2008) by extending existing supply chain ontologies with project specific concepts. Hence, our platform enables partners to reuse contextual knowledge in supply chain projects, and to share specific knowledge within the field of supply chain management. In addition, we contribute to faster calculations and simulations of dynamic supply chain environments by using structured ontologies extending template based research from Franzese et al. (2006).

By identifying relevant interfaces to ensure connectivity between information systems, we contribute with the *eighth publication* to a better understanding of cost drivers and business processes that influence connectivity between systems. In specific, firms miss technology maturity, availability of expertise, and an economical perspective on the cost to value ratio (Fontanella, 2004). Our research covers the RFID implementation steps and requirements of RFID systems including a calculation of integration costs beforehand; extending previous research on measuring the benefits of RFID systems after their implementation (F.-M. Tsai & Huang, 2012; Uckelmann, 2012).

We analyzed the literature and derived a new cost calculation method allowing us to identify and assign RFID-system integration costs. As a successive step, we developed the RFID cost calculator based on the identified integration costs. We evaluated iteratively the cost calculator using the “cognitive walkthrough method with users” in a laboratory setting, supported by interviews and open discussions. After the third evaluation round, the participants were satisfied with the calculator constituting no further needs to enrich the cost calculator.

As the tool includes technical and functional elements of RFID-systems and their cross-functional requirements, it can be applied in internal and inter-organizational settings. Hence, the tool can be used to calculate connectivity costs for related information systems at supply chain partners. Therefore, our research provides a tool allowing firms to align and enrich their information management capabilities, and contribute to theory by proposing a new cost calculation method covering all sorts of business processes for estimating the costs of RFID integration projects. This allows firms to reduce risks in case of integrating RFID system into the existing IT-landscape.

In the *ninth publication*, we proposed how supply chain partners can share information, using novel technologies (NFC and RFID) to apply information sharing in both directions. Our concept enhances partners to connect information systems for optimizing supply chain processes, and offer new services to patients. Further, our concept contributes to a higher availability and quality of used data combining a central (supply chain) information system and de-central applications on mobile devices. Besides using our previous results, we analyzed the pharmaceutical supply chain literature and enriched our practical knowledge by conducting a single-explorative case study within the pharmaceutical environment. Within this study, we gained insights on the market, order management processes, customer relationship management, and inventory management. This process ensures relevance of the developed prototype and rigor of the used knowledge base.

Our concept allows us to connect, share, and synchronize information in a bi-directional manner between pharmacies (supported by local information systems) and patients providing the opportunity for interaction between patients and pharmacies. Thereby, pharmacies can apply detailed information from patients for real-time planning affecting positively their inventories. In addition, pharmacies could avoid stock-out situations by improving their forecast accuracy. Further, patients can store their information on- and offline, depending on their preferences. In general, our concept allows firms to create patient-oriented solutions such as digital leaflets, individual intake information, further relevant information such as side effects with other drugs, individual reports, experience from other customers, or alternative treatments. In addition, our concept to store individual information on RFID tags, could, i.e. prevent patients adding expired drugs to actual ones, as they may interact badly. Hence, our concept increases the level of trust into information sharing, and provides an example on how different information systems and new technologies have to be adapted for mutual information sharing.

We use our findings on the antecedents on information sharing and comprehend them to derive guidelines for information sharing. In addition, we conduct a case study providing evidence that our applied findings (publication seven to nine) are useful, as analyzed firms neither have enough knowledge on supply chain management nor on information management capabilities (*tenth publication*). We found missing knowledge on how to connect information systems effectively and on how to make use of shared information. In addition, we found that firms struggle to decide what kind of information needs to be shared. Combining and relating our findings allows us to translate them towards information sharing guidelines for partners in supply chain relationships. Hence, our applied findings present first ideas on how to convert our guidelines into tools and concepts for information sharing in supply chains.

4.2 Implications for Research

This thesis has three main implication for research: (1) we provide a new perspective to analyze information sharing in supply chains, (2) our findings allow researchers to relate previous findings in one comprehensive matrix, and (3) we evaluate inter-relations between antecedents from different research streams providing an explanation for differences in information sharing behavior among supply chains and their partners.

Using game theory as theoretical lens, allows us to derive disseminated insights on information sharing in supply chains; thereby contributing to a rich and theoretical profound understanding of phenomenon on information sharing (Carter et al., 2014; Ellram & Cooper, 2014; Straub et al., 2004). Further, we contribute to supply chain management research by choosing an inductive research approach developing the matrix from exploratory case study findings, enriched by a structured analysis of literature (Ellram & Cooper, 2014).

In addition, as game theory has been used mostly in a quantitative context (Gérard P. Cachon & Kök, 2010; Nair et al., 2011), we enrich the theoretical perspective by using game theory to analyze information sharing from a qualitative angle (Carter et al., 2014). This approach allows us to explain why 90% of firms still avoid to share information although its positive effect on information sharing has been proven (Klein & Rai, 2009; Prokesch, 2010). More importantly, our matrix allows researchers to relate previous (and future) research findings by providing a profound base to explain inter-relations between antecedents on information sharing in supply chains. Therefore, researchers can use our matrix to combine, comprehend, and relate (their) findings.

In addition, we evaluate inter-relations between the following antecedents on information sharing in supply chains: bargaining power, trust, contract, information management capabilities, and supply chain knowledge. By developing a research model and evaluating its hypotheses, we combine antecedents from different research streams. Our findings provide evidence of the inter-relations, and provide the opportunity to organize the antecedents according to their importance for information sharing in supply chains using our matrix. Further, our findings provide evidence to distinguish the antecedents on information sharing from a firm´s perspective and from a supply chain perspective.

From a supply chain perspective, we found that bargaining power is used to initiate information sharing, strengthened by contracts, which enable a trustworthy relationship. Further, trust aligns information sharing realizing the highest level of information sharing by making use of information management capabilities and supply chain knowledge. Thereby, trust leverages mutual information sharing, while information management capabilities and supply chain knowledge are necessary conditions for achieving the highest level of information sharing. From a firm´s perspective, bargaining power is used to strengthen firm´s bargaining power position for negotiations, and contracts are used to establish punishment and reward mechanisms.

In addition, as previous research focused on analyzing the antecedents on supply chain performance (Klein & Rai, 2009), we focus our attention on the antecedents on information sharing. In contrast to previous research, we used information sharing as main construct and the other antecedents as sub-constructs on information sharing. Thereby, we found how antecedents are inter-related, and how they affect information sharing. Hence, we were able to apply our findings and propose first ideas on how antecedents have to be operationalized to enable and align information sharing processes within supply chains.

In consequence, by providing an explanation for differences in information sharing behavior among supply chain partners, and proposing first prototypes for information sharing, we contribute to a more nuanced understanding on how antecedents have to be enabled and aligned to ensure and realize mutual information sharing. Further, we provide a new theoretical lens to analyze information sharing in supply chains calling for future research using different research methods such as experiments, surveys, or simulations.

4.3 Implications for Practice

Practitioners can use our findings by (1) applying our information sharing guidelines, (2) creating awareness and a better understanding of inter-relations of analyzed antecedents on information sharing, and (3) reacting according to the information sharing behavior from supply chain partners in order to improve their supply chain performance.

Managers can use our findings and information sharing guidelines to develop an information sharing strategy. In specific, by responding to the information sharing behavior from supply chain partners, supply chain practitioners can align their behavior towards either defecting information sharing or not. This would allow firms to realize higher supply chain performance in case of mutual information sharing, and prevent firms from loses in case partners defect information sharing.

Further, as supply chain management affects many departments such as purchasing, logistics, or sales, we would recommend firms to introduce and monitor their supply chain performance with specific focus on information sharing at the level of directors. This would reflect and value the importance of information sharing for supply chains and their impact on the firm performance. Further, in case this initiative is supported by the higher management, it would allow managers to create an awareness for the importance of information sharing on supply chain performance. Moreover, having knowledge on the inter-relations of antecedents on information sharing, would allow supply chain managers to educate the employees at the supply chain department, and more importantly, discuss information sharing with supply chain partners in order to realize mutual information sharing among supply chains.

In addition, firms can use our prototypes to (1) realize a continuous exchange of supply chain knowledge, (2) improve collaboration at the supply chain level, (3) monitor and plan their supply chains more precisely by using existent data (thereby improving supply chain performance), and (4) improve their capabilities on information management.

In consequence, this thesis contributes to a higher awareness of antecedents on information sharing, its effects on firm´s performance and supply chain performance. Further, practitioners can use our findings and information sharing guidelines to manage and govern information sharing processes, and develop strategies for information sharing. However, the results of this thesis are limited (due to used research methods) and further research has to be conducted to ensure its usage in practice.

4.4 Limitations

All research has limitations, and this study is no exception. Most importantly, our findings span over a period of three and a half years. Therefore, our understanding continuously improved affecting the usage of terms (e.g. information management capabilities and supply chain knowledge), the application of methods (e.g. coding procedure of case studies), and the treatment of concepts (e.g. our matrix). Further, our results are affected by access to data such as ability to conduct a case study in firms. In addition, used research methods themselves are limited.

Case studies: While using qualitative research to derive theories is an appropriate approach (Eisenhardt, 1989b; Pettigrew, 1990), and case studies enable researchers to analyze multiple sources of evidence, they might capture only contemporary events (Yin, 2009). Therefore, future research should analyze our findings in a quantitative setting or by conducting a longitudinal case study. Furthermore, all cases are from different industries fostering theory validation and control for cross-industry variations. However, further empirical testing is needed to ensure a broad manifestation of our matrix and identified inter-relations (Eisenhardt, 1989b).

Literature review: Findings from our literature review are limited by the usage of keywords, used databases, and the criteria to filter the publications. Further, by selecting the keywords we limit the scope of the analysis reflecting a loss of opportunities, skipping articles in case of missing access, and the human bias in case of not considering an appropriate article (Okoli & Schabram, 2010).

In addition, using *design science* to apply findings and develop prototypes allowed us to achieve satisfaction of the experts, who evaluated the prototypes; thereby providing evidence that requested requirements have been developed appropriately. However, our experts represent only a small part of users. Therefore, our prototypes have to be tested in more longitudinal research such as field studies or by using quantitative research methods such as surveys or experiments.

In consequence, we can state that our findings are initial steps towards a better understanding of antecedents on information sharing in supply chains, while future research needs to replicate and validate our findings to ensure proper usage in practice, and usability for researchers to analyze information sharing in supply chains.

4.5 Future Research

As our findings are limited to the used research method, future research can verify and generalize our findings by quantitative research such as surveys, experiments, or simulations. This would allow researchers to verify the importance of antecedents on information sharing, and provide further evidence on the inter-relations of the antecedents.

Further, as we found that contracts and bargaining power play only a minor role for mutual information sharing in supply chains, future research could investigate their role more in depth. Additionally, further research could complement our findings with further antecedents such as leadership or culture as our results indicate the influence of further antecedents on information sharing in supply chains.

In addition, future research can advance our prototypes and evaluate their usability for information sharing among supply chain partners by using various research methods including longitudinal field studies or experiments. This would also allow researchers to validate and extend our information sharing guidelines. In specific, verifying our information sharing guidelines would enable researchers to develop information sharing strategies.

Furthermore, as our thesis contributes to mutual information sharing in supply chains and firms still struggle with how to share additional generated gains, future research could address this issue by developing an information system to monitor supply chain performance among all upstream and downstream partners. This would allow partners to monetize and share the additional gains in a fair manner, as this has to be found one main factor for mutual information sharing.

5 Conclusion

This thesis contributes to a better understanding on how various antecedents on information sharing in supply chains are inter-related and how the antecedents affect information sharing. First, we study how information is exchanged among information systems in supply chains, enriched by exploring antecedents on information sharing and a literature study on antecedents. Our results provide insights on how antecedents affect information sharing allowing us to develop a matrix to analyze differences in information sharing in supply chains. In addition, the matrix provides an explanation for the discrepancy between realizing the highest supply chain performance (by mutual information sharing) and having the highest risk to suffer from opportunistic behavior (in case of unilateral information sharing). Based on these findings, we evaluate inter-dependencies between antecedents and their impact on information sharing. In a fifth step, we use this model (and our previous findings) to develop prototypes to enable and align mutual information sharing among supply chain partners with specific focus on information management capabilities and supply chain knowledge. Based on our findings, we develop information sharing guidelines to manage and govern information sharing in supply chain.

In consequence, this thesis contributes to explain shifts in information sharing behavior in supply chains by using our matrix. Further, the matrix allows researchers to comprehend previous research on antecedents on information sharing in supply chains. Second, we evaluate inter-relations between antecedents on information sharing by conducting an explanatory case study. Third, we develop prototypes providing an idea on how to operationalize antecedents to enable and align information sharing in supply chains. This allows firms and supply chain partners to improve their supply chain performance. Supply chain practitioners can align their information sharing processes and develop information sharing strategies to improve their supply chain performance. Hence, our findings provide answers for the objective and sub-objectives of this thesis.

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PART B: Publications

The structure for each publication is as follows. First, each publication starts with a cover sheet, which includes the authors and the abstract of the publication. Second, each publication is summarized on one page. For each publication, an overview on how the author of this thesis has contributed to the publication has been added (as requested by the faculty of informatics from the Technische Universität München to receive the doctoral degree). Third, the publication is included[5].

[5] See also section 2.5 for further information.

Publication 1

A Comparative Analysis of Information Visibility in Two Supply Chain Management Information Systems

Title	A Comparative Analysis of Information Visibility in Two Supply Chain Management Information Systems	
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Abstract

Coordination in supply chains and networks calls for information sharing among the members of the supply chain. Accordingly, information visibility – the availability of relevant information for making supply chain related decisions is an important concept in the context of supply chain management. This study identifies the different dimensions of information visibility and proposes a framework based on these information visibility dimensions. The proposed framework can be used to evaluate supply chain information systems (SCIS) and their contribution towards information visibility in supply chains. Using the proposed framework, we compare two different SCIS (SAP APO and SupplyOn) to assess the extent to which these systems meet the information visibility needs within supply chains and networks. In order to carry out the comparison, data regarding the two systems in collected using multiple methods such as from system documentations, training sessions, interviews with experts and systems engineers. Our findings indicate that both systems perform well in terms of supporting information visibility. However, they serve different purposes within supply chains and networks. Based on the findings, we discuss the role of different types of SCIS depending on the characteristics of adopting firms and their supply chains, and how the use of these different systems

can complement each other. The research and practical implications of this study are discussed in the overall context of supply chain management. The framework can be used by organizations to assess the extent to which relevant information is accessible within their supply chains and to select from various SCIS solutions that are available. This research advances understanding on ways of achieving information visibility.

Individual contribution from Tobias Engel: I supported writing the Introduction, and the second chapter. Within the third chapter, we developed mutually the dimensions of information systems. Further, we jointly developed the fourth chapter. Moreover, we analyzed the chosen information systems based on the developed dimensions. In addition, I supported writing the Discussion, the Limitations and Future Research Section, and the Conclusion.

1 Introduction

Organizations view their supply chains and networks as critical determinants of efficiency and effectiveness in the face of rapidly changing and competitive business environments, short product lifecycles and rapid market fluctuations (Goswami, Ravichandran, Teo, & Krcmar, 2011; Hernndez-Espallardo, Rodriguez-Orejuela, & Sanchez-Perez, 2010; Lee, 2002b). Successful companies have identified collaboration (Olorunniwo & Li, 2010) along the supply chain as means for achieving heightened efficiency and better business performance (Lee, 2002b). This has resulted in a progressive transformation of supply chains towards inter-organizational supplier value networks (Goswami et al., 2011).

Information sharing is considered a prerequisite for cooperation in supply chains and networks (Olorunniwo & Li, 2010). Accordingly, there has been a significant research emphasis on the role of information sharing and information integration as means of achieving better supply chain performance (Rai, Patnayakuni, & Seth, 2006; Samaddar, Nargundkar, & Daley, 2006). Information sharing among members of a supplier network allows them to achieve the visibility that is needed to act upon changing business conditions, and the degree of visibility impacts performance gains within the supply chain (Lee, 2002a). To realize benefits within the supply network, members should have access to timely, relevant and accurate information (Rai et al., 2006). Despite this recognition, supply networks across industries suffer from poor and inexact information, delayed sharing of information and lack of information (Patnayakuni, Rai, & Seth, 2006; Straub, Rai, & Klein, 2004). In this context, it is believed that information systems can play an important role in enabling visibility in supply chains and networks, and accordingly firms adopt various information technology innovations to integrate and improve supply chain processes and networks (Christiaanse, 2005).

Supply chain management information systems (SCIS) enable integration along supply chains (Buxmann, von Ahsen, Díaz, & Wolf, 2004). These systems are used within a company or in inter-firm networks to execute integrated supply chain related business processes (Helo & Szekely, 2005). Benefits of SCIS include enhancement of productivity and lower operating costs (for instance, through reduction of inventory, improved service levels, etc.), access to timely information, increased flexibility and improved production planning, and enhanced resource control and asset management (Buxmann et al., 2004; Seidmann & Sundararajan, 1997). The highest benefits from these SCIS can be realized through using them in a shared collaborative environment (T. Mc Laren, Head, & Yuan, 2002). These systems contribute to value creation through information sharing and act as enabler for collaboration (Richard Klein & Rai, 2009; Lee, 2002b; Patnayakuni et al., 2006; Richard & Devinney, 2005).

A growing body of research has recognized the role of information systems in enabling sharing of information within supply chains and networks. For instance, researchers have focused on analyzing the nature of IT used in exchange relationships, and how information sharing can help in achieving supply chain process integration for performance gains (Rai et al., 2006; Subramani, 2004); how capabilities of IS applications deployed in inter-firm relationships can help in performance gains (Saraf, Langdon, & Gosain, 2007); and how the use of standardized IT applications can help firms in overcoming knowledge exchange barriers in inter-firm relationships and subsequently attain better performance (A. Malhotra, Gosain, & El Sawy, 2007).

However, there is a lack of systematic investigation on the extent to which commonly used SCIS satisfy the information needs of the different supply chain members. In particular, there is a scarcity of studies assessing the capabilities of large-scale information systems that are used at the network level (Reimers & Klein, 2006). SCIS are of different categories and fulfill different purposes within the context of supply chain management and integration. They have been classified as transactional systems that are meant from exchanging and processing operational information, and analytical systems that allow strategic analysis of supply chain related information (Helo & Szekely, 2005; Shapiro, 2002). Moreover, certain SCIS are more expensive and call for a larger resource investments on behalf of the adopting firm, while open-platform Internet based solutions provide a less expensive alternative for supply chain integration. Other factors such as complexity of implementation, maintenance cost, or the overall firm strategy regarding flexibility vis-à-vis structure may influence the decision regarding whether firms integrate best-of-breed solutions from different providers or choose all systems from a single provider (Light, Holland, & Wills, 2001; Olsen & Sætre, 2007). Therefore, deciding on an information systems solution for supply chains or networks is a complex task for firms with many different systems competing with each other.

Accordingly, there is a need to assess the extent to which different SCIS support the information visibility needs of the network, and provide a mechanism for evaluating different SCIS. This paper addresses this need by defining an evaluation framework for assessing the extent to which information visibility is supported by an SCIS. We then use the proposed framework to compare two SCIS that are commonly used for supply chain integration SAP Advanced Planning and Optimization (APO) and the SupplyOn systems.

2 Information as value enabler

An ability to sense where value lies within the supply network, and better coordination of activities in order to appropriate the value distinguishes high performing networks and organizations. In complex and dynamic business environments, integration of information flow is viewed as the most critical factor in enabling coordination in supply chain alliances (Hsu, Chiu, Chen, & Liu, 2009). Furthermore, firms need to understand how to use information effectively to manage processes (Miller, 1996). Information sharing can help organizations in anticipating opportunities within the network (Bovet & Frentzel, 1999; Samaddar et al., 2006), and thereby increase operational efficiency (Arvind Malhotra, Gosain, & El Sawy, 2005; Straub et al., 2004). For example, sharing information about the actual sales data at retail outlets allows manufacturers to better understand demand variations and thereby optimize their production capacities (Lee, Padmanabhan, & Whang, 1997). Buffers are common across any value network to deal with the uncertainties associated with demand and supply. An effective value network can allow firms to substitute information for these buffers and thereby increase agility in the network as well as reduce inventory costs, stock-out costs, or costs of marking down products (Choi & Sethi, 2010; Goswami et al., 2011; Magretta, 1998). In consequence, it can be stated, that information sharing is always beneficial (Gavirneni, Kapuscinski, & Tayur, 1999).

Previous research in supply chain management has highlighted the importance of information sharing. Simulations (e.g., (Cachon & Fisher, 2000)) and case studies (Ferdows, Lewis, & Machuca, 2004; Hammond, 1994) have confirmed information as an influencing factor for value creation in supply networks. Information sharing can help in achieving transparency for successful cooperation within the supply network (Sandberg, 2007), and is viewed as important for managing exchange relationships for value appropriation (Bovet & Frentzel, 1999; R. Klein, Rai, & Straub, 2007; Lee et al., 1997; Rai et al., 2006; Samaddar et al., 2006). Access to information that is relevant, timely and accurate enable network members to react to various events in a timely manner and therefore such information is considered to be of a higher quality (Wang & Strong, 1996).

Visibility of information along the supply chain enables firms to synchronize their production, improve forecasts, coordinate inventory decisions and develop a common understanding of supply chain performance (Lee & Whang, 2000; Simchi-Levi, Kaminsky, & Simchi-Levi, 2008). There can be different levels of visibility depending of the kind of information shared (Lamming, Caldwell, Harrison, & Phillips, 2001). The shared information can be classified as transactional, collaborative and strategic (Patnayakuni et al., 2006; Richard & Devinney, 2005). While the exchange of transactional information allows the execution of daily businesses (Lee, 2002b), the benefit of sharing strategic information is optimization of core processes within the supply chain (Richard Klein & Rai, 2009). Visibility enables firms to analyze operational information and increase operational efficiency (Ivert & Jonsson, 2010). Examples are inventory reductions among supply chain partners (Gavirneni, 2006b), better utilization of capacities due to improved production and delivery schedules and optimized demand and forecast planning (Lee et al., 1997; Lee, So, & Tang, 2000). Information sharing can also contribute to strategic achievements whereby firms realize intangible assets (Straub et al., 2004)such as strengthening bonds with customers and generating higher revenues (Anderson, Håkansson, & Johanson, 1994).

3 Dimensions of information visibility

The extent to which information is available to different members of the network will determine the visibility within the network. While there is a general recognition that visibility is a desired characteristic of the network, there is less agreement regarding what constitutes information visibility. Accordingly, there is a need to define information visibility and identify its dimensions. The identified dimensions can form the basis for evaluating different SCIS in terms of their ability to support information visibility in the network.

The different dimensions of information visibility are identified based on literature. We draw from information systems (DeLone & McLean, 1992; Miller, 1996) and supply chain literature (Closs, Goldsby, & Clinton, 1997; Huang, Lau, & Mak, 2003) to develop the three dimensions of information visibility. Information visibility refers to having access to relevant information that can be used for various supply chain related decision-making (Gulati & Kletter, 2005; 2007). Further, the information should be of a high quality (i.e., free of error), and it should be accessible in a timely manner (Straub et al., 2004; Wang & Strong, 1996). Therefore, we choose variety of information, quality of information and connectivity as the three dimensions of information visibility in this study. The dimensions described below allow us to answer the following question in the context of the two information systems that are being assessed: What and how much information can be shared between supply chain members using the SCIS? Is the shared information of a quality that allows makes them usable for the supply chain members? Does the SCIS allow supply chain members to connect seamlessly to other systems, either internal or external to the organization?

3.1 Variety of information

Variety refers to the different categories of supply and demand data that can be shared among firms. In practice, this includes inventory levels, sales data, demand forecast, order status, product planning, logistics, production schedules, etc. Sharing of inventory levels and sales data can help mitigating the bullwhip effect; sharing of performance metrics, such as product quality data, lead times, queuing delays, can help in identifying the bottlenecks within the chain and improve the overall performance (Lee & Whang, 2000). By sharing capacity information with the downstream partners, supply chain partners can coordinate their production on demand and prepare against possible shortages (Lee & Whang, 2000).

Therefore, variety of information means that the system can provide all information that is needed to support decision-making, to improve supply chain performance and to get the required visibility (Closs et al., 1997). In order to evaluate an SCIS, information variety can be considered to be made up of nine groups. These are master data, transactional data, demand information, inventory information, production information, transportation information, financial information, performance metrics, and alerts.

Master data includes structural information about the organization, its suppliers and customers, and basic data, referring to the infrastructure and production processes, like raw material belonging to a machine and its production process (Benz & Höflinger, 2011). Transactional data include customer orders, expected delivery date, etc (DeLone & McLean, 1992). Demand information provides forecast, information about promotional campaigns, and therefore serves as a critical source of information about future business (Gavirneni, 2006a; Ovalle & Marquez, 2003) Inventory information includes stock levels and decision models affecting order placements with supply chain partners (Gavirneni et al., 1999; Lee, Padmanabhan, & Whang, 2004; Ovalle & Marquez, 2003). Decision models are supported through expected service levels, inventory holding and backlog costs (DeLone & McLean, 1992).

Production information includes information about production lead-times, process steps, and durations and help in the execution of production planning and steering activities (Benz & Höflinger, 2011). Moreover, resource and capacity information are used to optimize material flows, thereby increasing efficiency (Lee & Whang, 2000). Transportation information includes delivery schedules and an overview to track and trace products along the supply chain to increase visibility and improve distribution processes (Helo & Szekely, 2005; Montgomery, Holcomb, & Manrodt, 2002). Financial information contains information about the value of products, tax related data and information regarding the processing of different types of invoices (Benz & Höflinger, 2011). Performance metrics are key performance indicators (KPI) that can support decisions for process improvements. KPI can assess inventory turn-rates, supplier performance, costs for special transports, etc. (Gunasekaran & Kobu, 2007). These metrics can be of internal or external use to monitor processes and alert firms in case of an exception (Montgomery et al., 2002; Saeed, Malhotra, & Grover, 2011).

3.2 Quality of information

The quality of information refers to the degree to which the information meets the needs of the organization (Rai et al., 2006). Quality of information ensures that information is of use for individuals, for the organization and the network (English, 2001), and is therefore an important factor affecting information visibility (Rai et al., 2006). Furthermore, the information characteristics and their perception define the quality of information (Miller, 1996). Therefore, based on a review of previous research, information quality is further defined using six characteristics: accuracy, availability, compatibility, completeness, confidentiality, and timeliness.

Accuracy ensures error free information (Closs et al., 1997). The information shared should be complete, accurate and objective data and in the right context for firms to be able to use it effectively (English, 2001; Kaipia, 2009; Ryu, Tsukishima, & Onari, 2009). Availability refers to information that is available and accessible in real time to align processes along the supply chain (Montgomery et al., 2002; Premkumar, 2000). Compatibility means that information can be shared and interpreted by the different systems without requiring major transformations (DeLone & McLean, 1992; Premkumar, 2000). Efficient information sharing implies that information is available in a timely manner (Kehoe & Boughton, 2001), enabling firms to react before a disruption impacts their operations (Li, Lin, Wang, & Yan, 2006). Finally, confidentiality implies that only authorized parties have access to the relevant information (Premkumar, 2000).

3.3 Connectivity

Connectivity refers to how the information is transferred among the different parties. Accordingly, connectivity can be divided into internal and external connectivity. Internal connectivity refers to exchange of information across functions within the boundaries of the firm, whereas external connectivity refers to the possibility of exchanging information across enterprise boundaries with customers, suppliers, 3rd party service providers and others (Closs et al., 1997).

Connectivity allows intra- and inter-firm information systems to be linked to improve process coordination. Use of internet-based systems and standardized supply chain processes offer potentials to improve connectivity (Bussiek, 1999). Connectivity can therefore support various concepts of collaboration and coordination among supply chain members such as Vendor Managed Inventory (VMI) and Collaborative Planning Forecasting and Replenishment (Nambisan, 2000).

The above dimensions (variety of information, quality, and connectivity) can be used as evaluation criteria to assess and compare different SCIS. Table 1 summarizes our evaluation framework based on these three dimensions of information visibility. We will use these evaluation criteria to assess and compare the SAP APO and SupplyOn systems.

Variety of Information	
Data Category	**Description**
Master data (Benz and Höflinger, 2011)	Organizational, infrastructure & material master data
	Supplier & customer master data
Transactional data (DeLone and McLean, 1992)	Historical data
	Customer orders
Demand information (Gavirneni, 2006, Ovalle and Marquez, 2003)	Demand forecast
	Promotional uplift
Inventory information (Gavirneni et al., 1999, Lee et al., 2004, Ovalle and Marquez, 2003)	Inventory level
	Location
Product information (Benz and Höflinger, 2011, Lee and Whang, 2000)	Bill-of-material
	Production planning & scheduling
	Quality requirements
	Resource & capacity information
Transportation information (Helo and Szekely, 2005, Montgomery et al., 2002)	Delivery schedule
	Order status for tracking & tracing
Financial information (Benz and Höflinger, 2011)	Value of product
	Tax related data
	Invoice type
Performance metrics (Gunasekaran and Kobu, 2007)	Logistic key performance indicators (KPIs)
Alerts (Montgomery et al., 2002, Saeed et al., 2011)	Notifications & exception alerts
Information Quality	
Quality Category	**Description**
Accuracy (Closs et al., 1997)	The extent to which information is error free
Availability (Montgomery et al., 2002, Premkumar, 2000)	The extent to which information can be accessed when and where desired
Compatibility (DeLone and McLean, 1992, Premkumar, 2000)	The extent to which information is capable of being used with or connected to other systems or components without modification
Completeness (English, 2001, Kaipia, 2009, Ryu et al., 2009)	The extent to which information is not missing and is of sufficient breadth and depth for the task at hand
Confidentiality (Premkumar, 2000)	The extent to which information is secured and available only to persons authorized to see and to use.
Timeliness (Kehoe and Boughton, 2001)	The extent to which information is current relative to the situation
Connectivity	
Connectivity Category	**Description**
Internal Connectivity	Connectivity with internal information systems and with internal functionalities

(Closs et al., 1997	
External Connectivity (Closs et al., 1997)	Data Exchange formats and integration with external systems and platforms

Table 1 – Dimensions of Information Visibility

4 Supply Chain Management Information Systems

Supply chain management information systems (SCIS) are software packages aimed towards performing a certain sets of tasks within the context of supply chain and networks. SCIS have evolved significantly over time in response to changing business models, rapid technological developments, a need to adapt to such changes and provide the functionality to support complicated and sophisticated business requirements (Barrett & Konsynski, 1982). Helo and Szekely (2005) provide a systematic overview of the evolution of SCIS, outlining different categories of such systems and the different purposes that they can serve. Therefore, for a firm considering the selection of a SCIS, very different types of systems compete with each other (Helo & Szekely, 2005). Therefore, there is a need to be able to assess these systems, their criteria for information sharing (Kristianto & Helo, 2010), and the extent to which they support information visibility as described in the previous section.

From a strategic management perspective, SCIS can be classified into intra-firm or inter-firm systems. While intra-firm systems operate within the boundaries of a firm, inter-firm systems allow process integration across firm boundaries. Accordingly, one of the desired characteristics of SCIS is internal compatibility with other information systems used within the organization and external compatibility with business partners (Buxmann et al., 2004). From a data management perspective, SCIS have been classified into transactional and analytical systems (Helo & Szekely, 2005). Transactional systems are used for acquiring, processing, and communicating raw data about the firm's supply chain operations. In contrast, analytical systems focus on strategic analysis of transactional data to develop decision models, and on the optimization of future planning and scheduling activities.

SCIS can be further classified into planning systems and execution systems from a process perspective. The planning systems use advanced algorithms and models to determine the best way to fill an order, while execution systems primarily deal with the physical status of goods, the management of materials and financial information involving all parties. Supply chain applications that are based on open-data models can support data sharing both inside and outside the firm. These extended-enterprise models contain key suppliers, manufacturers, and end-customers of a specific firm. Each of the different classes of SCIS identified above, have different ways of handling data and this can result in significant differences in terms of information visibility.

Using the classification schemes discussed above, SAP APO can be classified as an analytical system while SupplyOn can be classified as a transactional system. SAP is the leading supply chain application vendor with the largest market share (Trebilcock & Rogers, 2009), while SupplyOn is a successfully managed third-party hub which currently serves over 2700 suppliers primarily in the automotive and manufacturing industries (Howard, Vidgen, & Powell, 2006). SupplyOn has emerged as a leading multi-enterprise business process platform by processing raw data across organizational boundaries and can integrate business processes in the areas of sourcing, logistics, engineering, quality management, and finance. SAP APO focuses on forecasting, and planning for the future based on the transformation of transactional data with the aim of improving supply chain related decision making.

4.1 SAP APO

Planning is the critical first step in the process of achieving operational efficiencies within supply chains and networks. The SAP APO is primarily a planning tool supported by data from the SAP enterprise resource planning suite (SAP R/3), and the business warehouse suite (SAP BW). Firms cannot use SAP APO on its own, but have to use it in conjunction with the R/3 and the BW systems. The architecture of SAP APO (later on also referred as APO) is shown in Figure: 1 (Ivanova, 2009). The APO can be used as an analytical system that can simulate different scenarios using current and historical data from the other systems. Each business unit within the organization can be linked to the APO, and further, using enterprise application integration (EAI) platforms other customers and suppliers can also be integrated into the APO systems for the purpose of supply chain collaboration, such as through collaborative planning, forecasting and replenishment (CFPR) (Fliedner, 2003).

The supply chain processes covered by APO include demand planning, production planning and detailed scheduling, supply network planning and transportation planning. Demand planning includes forecasting figures for short-, mid- and long-term planning. The production planning and scheduling module allows the optimization of resource capacity utilization as well as the creation of detailed production schedules. Supply network planning optimizes the supplier order processing in conjunction with planned production schedules based on customer orders and available resources. Transportation planning is used to manage and optimize the distribution network in order to meet customer requirements. Since the planning and scheduling done by APO is based on actual transactional data from the ERP systems, there is visibility into inventory levels, delivery schedules, etc. Accordingly, simulations can be carried out over the entire supply chain, or parts of it.

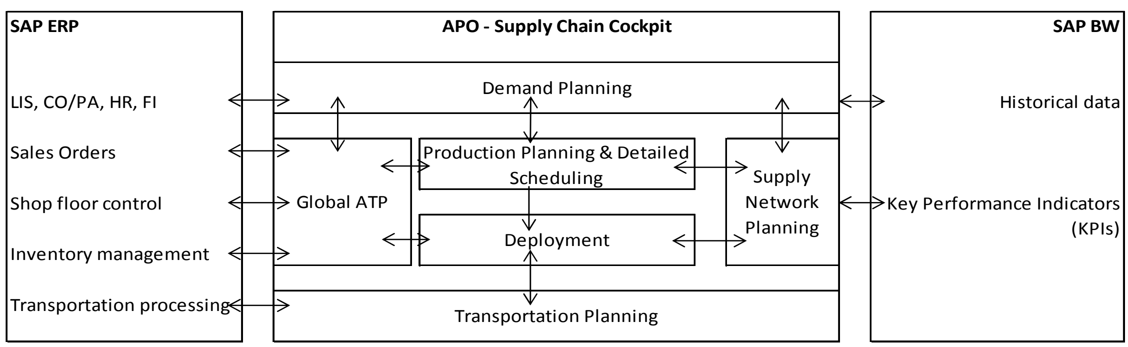

Figure: 1 – Schematic Overview of the SAP APO system

4.2 SupplyOn

SupplyOn provides an on-demand platform, which allows business partners to access and share real time information such as detailed information about production batches. Setting up the data structure that will be exchanged is the responsibility of SupplyOn's users. For communication between business partner's standardized formats (xml, Edifact, WebEDI, etc.) and transport protocols (ftp, http, etc.) are used. Therefore, SupplyOn is not limited to any specific architecture and can be connected to many information systems. However, the platform is not able to perform further actions with the data like scheduling or capacity planning. Therefore, it is classified as transactional system, acting as an intermediary in a global environment.

SupplyOn can be divided into four main categories, which focus on different supply chain processes (see Figure: 2 (SupplyOn-AG, 2011)). These are sourcing, quality, logistics and finance. For each of these four categories, further distinction is made between development and production phases. Sourcing deals with purchasing and related aspects such as identification of potential suppliers, request for quotation, and price negotiation. Quality deals with product quality planning, supplier rating and other aspects of quality management. Transfer of transactional data, like call-offs, delivery instructions, etc., as well as the possibility to have transparency of stock levels, implementation of vendor management inventory (VMI) and Kanban are supported within logistics. Finance deals with invoices, settlement advice, and remittance advice, although actual payments are not handled by the SupplyOn system.

SupplyOn relies on platform independency, usage of standardized communication formats, and the possibility for multiple connections between various business partners, for supporting "m:n-relationship".

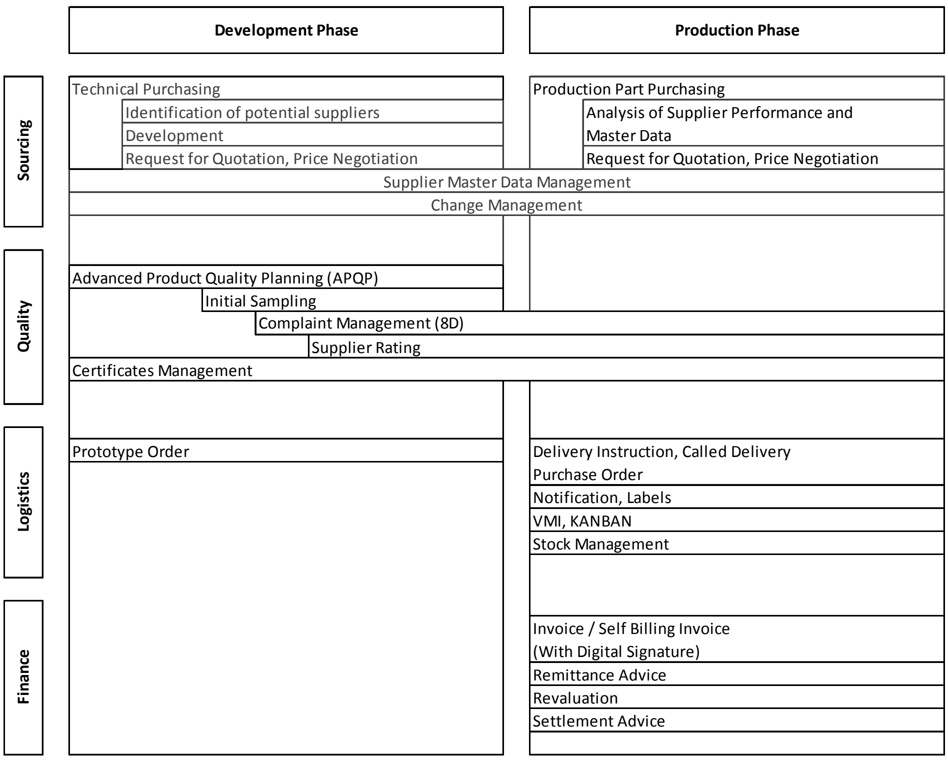

Figure: 2 - Overview of the SupplyOn System

5 Research Method

The information visibility dimensions and the various criteria listed in Table 1 are used to evaluate the two SCIS – SAP APO and SupplyOn. In order to assess the extent to which these systems satisfy our evaluation criteria, two independent researchers collected data from a variety of sources. In the first round of data collection, we systematically went through and reviewed the various system documents (functional documents, training documents, user manuals, etc.). This was then followed up with the researchers participating in two user trainings (two one day training, one for each system). Demo versions of the SAP APO system hosted in the university competence center (of the researchers' home university) was independently reviewed by the researchers in order to get a better understanding of the different information and processes support by SAP APO. For SupplyOn, we were able to obtain a two-week access to a demo instantiation of the system that is used by SupplyOn for providing client trainings. Having access to both systems over a prolonged period of time helped us in assessing them in an objective and detailed manner, and provided us with valuable insights into the systems. This helped us in getting a better understanding of both systems, the different supply chain processes and functions they supported, and the kind of information that could be shared using the system. Following this, we carried out four interviews with support engineers from both SAP and SupplyOn to clarify any further doubts regarding the systems, and to validate our findings and assessments regarding the functionality afforded by these systems. These were semi-structured interviews with each interview lasting over one hour. The interview data were reviewed to analyze the extent to which these systems supported information sharing and assign the scores (reported in Table 2, 3, and 4).

5.1 Assessing Information Visibility in SAP APO and SupplyOn

Table 2 indicates the extent to which SAP APO and SupplyOn meet the criteria for variety of information. The last two columns in the table indicate whether or not the particular information type can be shared using the system.

Since SAP APO uses transactional data from the SAP R/3 ERP system, it has access to all relevant information regarding products, customer orders and their current status in the inter-company supply chain, production plans, inventory related information. In contrast, SupplyOn only supports the sharing of basic data about inventory planning, and delivery schedules (such as truck pick-up times), used primarily for communication and reporting. It does not support the sharing of forecasting and scheduling information, and further does not support any kind of transformation on the shared information. SupplyOn further supports the sharing of financial information, which is not provided by the SAP APO system.

Our analysis indicates that SAP APO provides more breadth in terms of the variety of information that it supports (Table 2). Accordingly, it can be stated that SAP APO can be used as a steering tool within the supply chain or network, while SupplyOn is more suited for sharing basic information among network members.

Variety of Information			
Data Category	**Description**	**SAP APO**	**SupplyOn**
Master data	Organizational, infrastructure &	Yes	No

(Benz and Höflinger, 2011)	material master data		
	Supplier & customer master data	Yes	Yes
Transactional data (DeLone and McLean, 1992)	Historical data	Yes	No
	Customer orders	Yes	Yes
Demand information (Gavirneni, 2006, Ovalle and Marquez, 2003)	Demand forecast	Yes	No
	Promotional uplift	Yes	No
Inventory information (Gavirneni et al., 1999, Lee et al., 2004, Ovalle and Marquez, 2003)	Inventory level	Yes	Yes
	Location	Yes	No
Product information (Benz and Höflinger, 2011, Lee and Whang, 2000)	Bill-of-material	Yes	No
	Production planning & scheduling	Yes	No
	Quality requirements	No	Yes
	Resource & capacity information	Yes	No
Transportation information (Helo and Szekely, 2005, Montgomery et al., 2002)	Delivery schedule	Yes	Yes
	Order status for tracking & tracing	Yes	No
Financial information (Benz and Höflinger, 2011)	Price, tax-related data, invoicing	No	Yes
Performance metrics (Gunasekaran and Kobu, 2007)	Logistic KPI´s	Yes	No
	Supplier Assessment	No	Yes
Alerts (Montgomery et al., 2002, Saeed et al., 2011)	Notifications & exception alerts	Yes	Yes

Table 2 – Analysis of Variety of Information

For assessing the different criteria of information quality, we used a three level scale where “High” indicates that information quality is assured, “Medium” indicates that information quality is partly met, and, “Low“ means that there is no assurance of information quality. Table 3 shows the comparison between SAP APO and SupplyOn.

Information Quality		
Quality Category	**SAP APO**	**SupplyOn**
Accuracy (Closs et al., 1997)	Medium	Medium
Availability (Montgomery et al., 2002, Premkumar, 2000)	High	High
Compatibility (DeLone and McLean, 1992, Premkumar, 2000)	High	High
Completeness (English, 2001, Kaipia, 2009, Ryu et al., 2009)	High	Medium
Confidentiality (Premkumar, 2000)	Medium	High

Timeliness (Kehoe and Boughton, 2001)	High	Medium

Table 3– Analysis of Information Quality

In SAP APO, data accuracy is determined by the extent to which data is accurate in the base systems (R/3 or BW). Therefore incomplete or missing data, particularly for data that is generated through manual entry in the base systems will affect the accuracy of SAP APO. Similarly, in SupplyOn, the accuracy is determined by the quality of the input files or errors in manually entered information (since not all firms use automatic data transfer). Therefore, both systems are rated as medium in terms of data accuracy.

Availability is high for both systems, since they are accessible anytime and from anywhere using Internet enabled access. Both SupplyOn and SAP APO are capable of receiving and transferring data over standardized interfaces and protocols, which results in high levels of compatibility. In terms of completeness, the APO system has access to more complete information for planning and coordinating complete supply chain processes (intra-firm processes, as well as inter-firm processes). In contrast, SupplyOn is not suitable for coordinating and integrating intra-firm processes, but is primarily targeted towards exchange of transactional information across firm boundaries.

Both systems ensure confidentiality using access control through authorization. However, SupplyOn implements a stricter access control by means of digital signature verification, particularly for the exchange of financial information. Timeliness refers to the extent to which the information is current. SAP APO is directly connected to SAP R/3 system, which collects data from machine subsystems, logistic subsystems and other systems within the firm that support real time updating of information. SupplyOn primarily carries out data transfers across firms based on automated hourly, daily, weekly transfer, or manual transfers.

Table 4 shows the analysis of SAP APO and SupplyOn in terms of connectivity. SAP APO is usually integrated with SAP R/3 and BW systems, and can also be connected with the SAP Event Management systems and the SAP Inventory Collaboration Hub. Therefore, in terms of functionality, SAP APO can connect with procurement, manufacturing, and logistics system. SupplyOn can be run as an integrated web-based SCM solution, and can be connected with various functional systems (such as existing ERP systems, inventory systems, etc.).

In term of external connectivity, both SupplyOn and SAP APO support open interfaces and standards. SAP APO can be integrated with various kinds of data acquisition technologies, such as direct entry, Spreadsheets, EDI, XML, FTP, RFID and it can be linked to other non-SAP systems. On the other hand, SupplyOn supports EDI and WebEDI for exchanging information. WebEDI is EDI messages as Web forms, which the suppliers receive via the Internet in a straightforward manner. Internet data exchange is based on the XML format.

Connectivity			
Connectivity Category	**Description**		
Internal Connectivity	Connectivity with internal information systems	SAP R/3, BW, EM, ICH	Integrated web-based SCM solution

(Closs et al., 1997	Connectivity with internal functionalities	PUR, MM, PP, Log, SD, HR, CO	Integration of internal system
External Connectivity (Closs et al., 1997)	Data Exchange formats and integration with external systems and platforms	Direct-Entry, WWW, EDI, XML, FTP, RFID, Barcode, Spreadsheets	Direct-Entry, WWW, EDI, XML, FTP, Web-EDI, Barcode

Table 4 – Analysis of Connectivity

5.2 Implications of SAP APO and SupplyOn on Information Visibility

SAP APO and SupplyOn have fundamentally different approaches towards information sharing. While SupplyOn is primarily meant to be used as an integration tool across firm boundaries, SAP APO is used for advanced supply chain operations such as planning, forecasting, and optimization through close integration with other SAP systems. Despite these differences, both systems provide significant support for information visibility. SAP APO and SupplyOn are very similar in the extent to which they satisfy the requirements for information quality and connectivity. For variety of information, SAP APO has access to and therefore supports the sharing of a wider spectrum of information that are relevant from a supply chain management perspective.

While SAP APO provides advanced features and capabilities for planning and optimization within and across firm boundaries, these features require the availability of data from other internal SAP systems. Therefore, using SAP APO to integrate with a supply chain partner that does not also have SAP systems prevents firms from realizing the full potential of SAP APO (Monge et al., 1998). In such circumstances, SupplyOn may be more suitable for achieving information visibility within the network, as the web-based structure of SupplyOn allows platform independence for firms sharing supply chain information.

6 Discussion

SCIS are critical for synchronizing information among members of supply chains and networks, and accordingly there is a need to better understand the similarities and differences between different SCIS in order to be able to carry out a systematic evaluation and selection of such applications (T. S. Mc Laren & Vuong, 2008). Our paper contributes towards this by developing an evaluation framework for assessing information visibility in different SCIS. The framework is based on the identification of three information visibility dimensions – variety of information, quality of information and connectivity.

We use this framework to compare two different SCIS and assess the extent to which they satisfy information visibility criteria. The two SCIS are analyzed and compared based on the relative presence or absence of functionalities, which allow them to fulfil the information visibility requirements within a supply chain or network. Our assessment indicates that both systems can serve the purpose of increasing information visibility among firms in supply chains or networks.

Firms, using the SAP APO system or other SAP systems (such as R/3, BW, etc.), have to invest in them simultaneously. SupplyOn on the other hand does not depend on any specific system and can be relatively easily integrated with any other system. Therefore, SupplyOn calls for less investment effort on the firm's behalf. SupplyOn is an attractive option for smaller firms who need to coordinate with larger manufacturers, or integrate with other firms within their networks. It supports both data exchanges and supply chain process integrations using standardized interfaces. Accordingly, SupplyOn is also used as a supporting system for locally installed ERP and SCM systems within firms. For larger firms, the choice of the SCIS could be based on factors such as whether or not they have large-scale ERP systems, the characteristics of their supply chain /network and the IT infrastructure and capabilities of their trading partners. For example, a large firm may consider adopting SupplyOn when they want to exchange information with multiple suppliers, whereas, a one-to-one relationship with a major supplier or buyer could be managed by integrating using SAP APO. This research distinguishes between the characteristics of two different breeds of SCIS, and can act as a guide for practitioners to select the right system based on their supply chain strategy and the needs of the supply network. The importance of such guidance is further underlined by the fact that multi-tiered and interconnected supply chains require different information technology solutions compared to inter-organizational systems for point-to-point connection (Steinfield, Markus, & Wigand, 2011).Moreover, the research allows firms with focus on supply chain management to align processes by selecting appropriate systems supporting information visibility. From a theoretical perspective, our paper contributes towards existing literature in information visibility in supply chains and networks by reviewing the role of information sharing and identifying the three critical dimensions of information visibility to assess different SCIS. The dimensions of information visibility can be used to not only compare different SCIS, but also be used to further analyze the role of information visibility in various supply chain related decisions and outcomes.

7 Limitations and Future Research

Our research results are limited as we compare two different types of SCIS, used to serve different supply chain functions. Additional research is needed to generalize our findings, such as by comparing similar systems (for example, comparisons between multiple analytical systems that are similar to SAP APO, and comparisons between multiple web-based systems such as SupplyOn). However, by assessing two seemingly different systems, our research provides a more holistic view on information sharing in supply chains. Our findings and analysis indicate that both systems can complement each other by contributing to information visibility either on a supply network level, or on a point to point relationship in the supply chain level.

Our analysis relies on interviews with software engineers, documentation, training material, and an analysis of the two systems by the researchers. Future research can be used to strengthen our findings by conducting case studies to investigate various implementations of SCIS in business settings, and analyze the extent to which they satisfy the information visibility requirements in the context of their use. Future research can also investigate the extent to which these information visibility dimensions actually result in better coordination and decision-making in supply chains and can attribute to performance gains. For instance, case studies and surveys could be used to get a better understanding of supply chain practices and the current state of information visibility within supply chains and networks. Further, simulations can be carried out to investigate the relationship between the different levels of the three information visibility dimensions and supply chain performance.

Further, detailed case studies can be used to investigate the level and patterns of information sharing within supply chains and networks: Which information is shared? How much information is shared? With whom is information shared? What factors determine the level of information shared? A more detailed analysis of information sharing patterns would help to understand supply chain performance and differences between firms in a supply chain. In a consecutive step, it would be helpful to analyze how different SCIS address the information sharing needs and information sharing patterns of firms in the supply chain in certain industries, and for different products.

8 Conclusion

This research provides a framework developed from literature to compare SCIS and to analyze information sharing capabilities of SCIS. The framework is based on three major dimensions of information visibility, and therefore enables practitioners and researchers to identify the strengths and weaknesses of SCIS at a detailed level of analysis. From a practical standpoint, the findings from this research has significant relevance for supply chain and network practitioners by allowing them to analyse and choose a SCIS solution that is the most suitable for their firm based on the characteristics of their supply chain and network. Researchers can use this framework to analyze various supply chains and networks, and identify the relationship between the various information visibility dimensions and their implications on supply chain performance.

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Publication 2

How Supply Chain Governance Influences Information Sharing Behaviors: A Multiple Case Study Approach

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Abstract

Information sharing within the supply chain is an important factor for effective supply chain management. Having access to the right information allows firms to coordinate activities and collaboratively manage supply chains to realize higher performance. Despite this, there exists significant difference in information sharing behaviors among supply chain members. Using an exploratory case study approach, this research identifies the factors that determine differences in information sharing. Classifying the supply chain governance competencies of supply chain members along three dimensions, technical, advanced technical and relational, we analyze the implications of these three dimensions on the overall information sharing behavior of the firm. Based on an in-depth analysis and comparison of four retail supply chains, we identify different information sharing patterns and the factors contributing to the identified patterns. In particular, it was found that while the technical competency (primarily derived from the use of information technology applications) is necessary, it is not a sufficient condition for collaborative information sharing behavior. Relational competencies play a more important role in facilitating information sharing. Based on the findings from the four cases, we come up with propositions outlining different information sharing patterns in supply chains.

Individual contribution from Tobias Engel: I was in charge of writing the Introduction, the Theoretical development chapter, and had the lead on the Research Method. Further, we analyzed the transcripts commonly, discussed, and presented the results. A first version of the Discussion, the Limitations and the Conclusion chapters has been written by me. This was followed by an iterative process, in which comments from all co-authors were addressed. Final adjustments were done commonly.

1 Introduction

Supply chain management initiatives enable firms to improve operational processes such as inventory levels, and achieve higher revenues and better margins (Swink, Golecha, & Richardson, 2010). Inter-organizational information systems are often used to support new supply chain management initiatives, as they can improve inter-firm information sharing. Firms are able to realize cost savings and improve processes through information sharing (Clark & McKenney, 1994; Enslow, 2006). Accordingly, supply chain members have recognized the importance of information sharing as an essential factor influencing supply chain performance (Barrett & Konsynski, 1982; H. L. Lee, So, & Tang, 2000; Rai, Patnayakuni, & Seth, 2006).

The benefits of information sharing are well recognized (e.g., Klein & Rai, 2009), and various information technology solutions for sharing information and integrating supply chain processes are available; however, firms may still avoid sharing information with their upstream or downstream partners (e.g. Karen, 2010; H. L. Lee, Padmanabhan, & Whang, 1997). Selfish enhancement of their own competencies, increasing bargaining power within a relationship, and the ability to influence terms and conditions in their own favor through control over strategic information are some of the factors that prevent firms from sharing supply chain information (Argyres & Liebeskind, 1999; Nair, Narasimhan, & Bendoly, 2011). As a result, varying forms of information sharing behaviors can be observed within supply chains.

Real life examples also indicate the existence of different information sharing behaviors among supply chain members. For instance, Dell uses its strong bargaining power to integrate upstream supply chain partners into its information flows and material flows, and applies daily information sharing routines to achieve a negative cash-conversion cycle of five days and other process improvements (Magretta, 1998). Toyota and Zara on the other hand achieve a more collaborative and more cost efficient network by setting up routines for knowledge and information sharing (Dyer & Nobeoka, 2000; Ferdows, Lewis, & Machuca, 2004).

Information sharing among supply chain members is complicated by factors such as cultural issues and incentives (Karen, 2010), trust and beliefs (Petersen, Ragatz, & Monczka, 2005) and data quality concerns (Forrester, 1961). Previous research and empirical findings in the field of supply chain management and information systems confirm the importance of information management competencies of firms, also referred to as supply chain governance (e.g., Sunil Mithas, Ramasubbu, & Sambamurthy, 2011; Rai et al., 2006), and their (socio-) political behavior (Kumar & van Dissel, 1996; H. L. Lee et al., 1997) as two major factors influencing information sharing in supply chains. Further, it has been shown that incentive alignment results in higher performance (Agarwal, Croson, & Mahoney, 2010; Patnayakuni, Rai, & Seth, 2006; Straub, Rai, & Klein, 2004).

However, existing research contributes little towards understanding the various initiatives for successful information sharing among supply chain members (Emberson & Storey, 2006; Ketchen & Hult, 2007). In practice, it is often observed that most firms still tend to share solely transactional information and are not able to accomplish information visibility (e.g., Karen, 2010; Prokesch, 2010). Our research addresses this gap by analyzing differences of information sharing behavior among supply chain members using an exploratory case study approach, and factors that determine information sharing. Based on a classification of different supply chain management competencies, we analyze information sharing in four different retail supply chains. Our analysis provides insights on what the information sharing process looks like, what factors trigger information sharing, and how supply chain governance mechanisms affect information sharing in supply chains.

The rest of the paper is organized as follows. The second section provides the theoretical background of information sharing, incentive alignment and supply chain governance competencies in the field of supply chain management. This is followed by a description of our research methodology. The fourth section presents the results of the case studies, followed by a discussion of the findings from the case studies. We conclude with a discussion of limitations of the current study and implications for future research.

2 Theoretical Development

Collaboration among supply chain members positively affects information sharing allowing firms to increase their firm performance (Sunil Mithas et al., 2011; Straub et al., 2004). Firms can realize the highest profits through jointly generated exchange relationships (Dyer & Singh, 1998). Nevertheless, firms may have strategic considerations that prevents them from collaborating (H. L. Lee et al., 1997). For instance, a specific isolated behavior can often result in a tit-for-tat strategy causing lower rents (Axelrod, 1984). Firms experiencing operational inefficiencies in combination with uncooperative behavior in buyer-supplier relationships often establish several actions to counter such behavior. These actions may include information sharing (Fangruo, 1999), business process reengineering (Disney & Towill, 2003) and contractual safeguards (Mason-Jones & Towill, 1997). Due to the importance of information sharing for supply chain performance, and the strong association between information sharing and incentive alignment, this research explores the relationship between information sharing and incentive alignment, and information sharing behavior from a supply chain governance perspective.

2.1 Information sharing and incentive alignment

In supply chains transactional information sharing is a necessary condition to streamline the exchange of goods, and the sharing of operational information allows firms to establish more efficient supply chain procedures and actions (Seidmann & Sundararajan, 1997). More importantly, sharing of operational and strategic information can generate additional rents and improve supply chain performance (e.g., Klein & Rai, 2009; H. L. Lee, Padmanabhan, & Whang, 2004).

However, organizations may choose not to share information when it is perceived that information asymmetries can be used as a source of competitive advantage and rent generation, especially when relationships are more opportunistic and/or purely transactional (e.g., Argyres & Liebeskind, 1999; Nair et al., 2011). A fair distribution of risks, costs and rewards, and a growing interdependence among individual actors in the supply chain can result in less opportunistic behavior and consequently higher supply chain performance (e.g., Granovetter, 1985; Provan, 1993).

Incentive alignment means that all supply chain members will gain from cooperation through economic value creation (Agarwal et al., 2010). Incentive alignment allows firms to lower risks by fairly distributing rewards, costs and risks among supply chain members (e.g., Cachon & Lariviere, 2005; Narayanan & Raman, 2004). More specifically, incentive alignment encourages information sharing routines and can allow firms to improve supply chain performance. In contrast, an asymmetry of information or knowledge, representing misaligned incentives, results in a lower supply chain performance (Narayanan & Raman, 2004). Previous research has shown that economic incentive alignment is influenced by the level of trust (e.g., Cachon & Lariviere, 2001; Klein & Rai, 2009), cultural aspects (e.g., Braunscheidel, Suresh, & Boisnier, 2010; Dyer & Nobeoka, 2000) and supply chain governance capabilities (Godsell, Birtwistle, & van Hoek, 2010; Harland & Knight, 2001). Accordingly, the difficulty in designing an incentive system is high (Tosi, Katz, & Gomez-Mejia, 1997).

2.2 Supply chain governance

Supply chain governance is a complex concept that can be determined by different factors. On one hand, the ability to effectively govern the supply chain can be characterized by technical factors such as efficiency of data management. On the other hand, supply chain governance capabilities can also be characterized by relational factors such as trust or bargaining power (e.g., S. Mithas & Lucas, 2010; Williamson, 1989). Therefore, it is possible to conceptualize supply chain governance as a multi-dimensional competency where each dimension reflects the different perspectives towards managing supply chains. In the following paragraphs, we elaborate on the three different dimensions of supply chain governance that we use to analyze our cases.

The technical dimension of supply chain governance analyzes the usage, setup and efficiency of data management within information systems. Under this dimension of supply chain governance, we examine the information systems that are implemented in the supply chains, and study the connections and linkages between the systems. Based on the state of implemented information systems, their connectivity, and the efficiency of data management, from a technical perspective, supply chain governance can be classified into poor, satisfactory and excellent (Sanders & Premus, 2002).

The advanced technical dimension of supply chain governance characterizes the process of information sharing among supply chain members. More specifically, we distinguish between the type of information shared such as, transactional, operational and strategic information. Secondly, we examine the frequency of information sharing between the supply chain members. Finally, we analyze the extent to which collaborative usage of the shared information affect decision making.

The relational dimension of supply chain governance analyzes information sharing behaviors from a socio-political perspective based on factors such as trust, length of relationships and bargaining power among supply chain members. Trust strengthens supply chain relationships, motivates firms to invest into long-term relationships, reduces uncertainty, fosters satisfactions and allows firms to establish information sharing routines (e.g., Zaheer, McEvily, & Perrone, 1998).

Supply chain governance competencies enable firms to align their processes, prevent conflicts in inter-firm relationships, improve information sharing, and therefore gain a competitive advantage (e.g., Ghosh & Fedorowicz, 2008). Table 1 provides an overview of the three dimensions of supply chain governance.

Technical	Advanced technical	Relational
Implemented information systems	Type of shared information	Trust
Connections between systems	Frequency of information sharing	Relationship length
Data management	Decision making	Bargaining power

Table 1 – Different Dimensions of Supply Chain Governance

3 Research Method

For this research a qualitative multiple-case study was chosen to explain information sharing patterns in retail fashion supply chains (A. S. Lee & Baskerville, 2003; Yin, 2009). Considering the guidelines from Myers and Newman (2007), we developed a semi-structured interview guideline from literature and executed a pre-check with five supply chain management consultants from a multinational consulting firm. This pre-check resulted in a reduction from 37 questions to 32 questions and ensured the right focus, an ordered structure of the questions and extensive coverage of the topic. Additionally, prior to administering the semi-structured interview guideline, they were checked by two independent researches not involved in the research; this process ensures construct validity (Yin, 2009).

For the case studies, 59 managers from 38 firms in the fashion retail industries were contacted via social networks, E-Mail and phone. Four firms were willing to support our research. Within the four firms, we identified five relevant interview partners from the top management and senior management level. The interviewees were chosen for their knowledge and responsibility for their firm´s supply chain management. The one-on-one interviews were undertaken partly personal, partly over phone and took place from the 16th January 2012 to the 18th June 2012 in the UK and in Germany. Each interview was audio-taped and lasted about an hour, on average. Additionally we reviewed internal documents about the material flows and information flows. In order to clarify statements, which were either unclear or in conflict with the documents, we conducted follow-up conversations with three interviewees from two firms via E-Mail. After thirteen interviews including the follow-up process and the pre-check, saturation was reached, giving us the confidence in our results as no additional critical enrichment of our data could be achieved (Eisenhardt, 1989; Thietart, 2001; Yin, 2009).

In order to ensure the quality of our research design, we ensured construct validity, internal validity, external validity and reliability of our findings (Eisenhardt, 1989; A. S. Lee & Baskerville, 2003; Yin, 2009). We derived ten code words from the three dimensions of supply chain governance followed by a transcription and coding of the interviews using the software MAXQDA. Furthermore, to ensure the reliability of the results, the transcripts were independently coded by two researchers, allowing us to perform a qualitative content analysis (Krippendorff, 2004). Moreover, we ensure internal validity by addressing the tactic of rival explanations and independently analyzed interviews. By limiting the research domain to fashion retail supply chains and using replication logic, we additionally ensure external validity of our findings. Finally, the structured interview protocol and interview transcripts were used to assure the comparability of findings, enabling us to gain greater insight into fashion retail supply chains and their practices of information sharing. By ensuring compliance with the validity requirements for case studies, we are able to generalize from an empirical description towards propositions for information sharing in supply chains (Eisenhardt, 1989; A. S. Lee & Baskerville, 2003; Yin, 2009).

4 Results of the case studies

This section presents the results of the case analyses to explain differences in information sharing behavior among supply chain members. The four apparel firms are referred to as Alpha, Beta, Gamma and Delta, in order to meet confidentiality requirements. The four analyzed firms offer high quality fashion products within the medium (Alpha, Beta and Gamma) and premium (Delta) price segment. Further, while Alpha, Gamma and Delta mainly offer clothes and some accessories such as perfume and bags, Beta offers a wide variety of products from clothes over shoes to bags for all kind of activities. Despite that difference, all four firms focus on selling clothes.

The headquarters of all firms are located in Europe. However their production facilities and suppliers are mainly located in Asia. The only exception is Beta, which finalizes variants for some special products in Europe. Furthermore, firm Beta has more than 300 suppliers, where more than two third are located in Asia; the rest is spread over America, Europe and Africa. The number of suppliers from firms Alpha, Gamma and Delta range from about 35 suppliers (firm Delta) to 130 suppliers (firms Alpha and Gamma). Despite the differences, all firms use similar distribution channels, including own retail shops, e-commerce, wholesale and franchise. Furthermore, Beta and Gamma also have factory outlets and Beta invests in joint ventures with other firms. The main customer base of the firms is located in Europe, America and Asia.

Beta is the largest firm in terms of revenues and number of employees, while Delta is the smallest firm. Table 2 provides further details of the cases.

	Employees	Revenues (in Mio. Euro)	Revenues/Employee
Alpha	1,200	350	291,667
Beta	46,000	12,000	260,870
Gamma	6,600	2,000	303,030

Table 2 – Further Details on the Four Firms

4.1 Technical supply chain governance

We analyzed the basic technical setup of information systems and the information management efficiency within the firms summarized in Table 3. We found that all firms except Alpha use enterprise resource planning (ERP) systems to share information with their suppliers. Beta and Gamma use SAP system, while Delta uses Intex, an ERP system specially developed for the apparel industry. However, a poor implementation of (the Intex) modules and an unsatisfactory user-interface results in poor information sharing processes and negatively affects the efficiency of internal business processes.

"[…] no one likes to work with the system. It has been introduced, and now there is no other chance than to accept it." (Delta, Paragraph No. 28)

The use cases and deployment of ERP systems within the firms varies. Delta uses Intex to share only transactional information. In contrast, Beta makes use of all standard ERP modules, while Gamma uses its ERP system mainly for purchase orders. The aligned system and modules in Beta ensure no media disruption and allow operational and strategic information sharing. Beta also uses an add-on for retail supply chains from the same vendor. Moreover, Beta deployed the business intelligence and forecasting modules from SAP to ensure an easier and faster report compilation as several reports are pre-defined, and can be used as template for further reports.

"[..] we have the Business Intelligence module from SAP to create reports […] some important reports are already pre-defined […]." (Beta, Paragraph No. 252)

Alpha has no ERP system implemented yet and they share transactional and operational information with their suppliers via E-Mails using Excel files. This also implies that all information is internally shared and exchanged via E-Mail, phone and fax. Therefore, it can be assumed that the understanding of the effect of information sharing on supply chain performance is low as reflected by the usage of stand-alone solutions and internal and external information sharing processes.

"We currently have no supply chain management software. […] We work with Excel […]. Information Sharing is done via E-Mail, phone and Fax." (Alpha, Paragraph No. 58, 60, 66)

Technical Supply chain governance	**Alpha**	**Beta**	**Gamma**	**Delta**
Implemented information systems	No ERP system	SAP, SAP Retail, SAP BI	SAP	Intex
Connections between systems	E-Mail, Fax, Phone	EDI, Fax, Phone	E-Mail, Fax, Phone	E-Mail, Fax, Phone
Data management	Poor	Excellent	Satisfactory	Poor

Table 3 – Comparison of the Technical Supply Chain Governance Dimension

4.2 Advanced supply chain governance

The analysis of the second supply chain governance dimension reveals different information sharing behaviors among supply chain members (see Table 4). Gamma and Delta share only transactional information with their suppliers, while firm Beta shares operational and strategic information such as production schedules. Alpha stated that they share operational and strategic information; however, they were not willing to share further details. Therefore, this statement has to be considered with caution.

"[…] basically order information and forecast information is shared." (Alpha, paragraph No. 112, 116)

Although the type and level of exchanged information vary, the frequency of information exchange among all investigated firms is the same. All firms contact their suppliers several times a day to forward purchase orders, instruct changes and check the status of the production.

"Information is shared on a daily basis, and when it is necessary." (Alpha, paragraph 66); "[…] we have a daily information sharing process." (Delta, paragraph 72)

The degree of decision making differs among the four supply chains. In the case of Beta, the long-term suppliers and Beta collaboratively decide on replenishment and forecasting figures. However, the other three firms do not see any value in collaborative decision making.

"[…] we will share any information which is needed to supply the goods on time, but we do not see any additional value to share Point-of Sales-Data." (Alpha, paragraph 18)

Advanced technical supply chain governance	Alpha	Beta	Gamma	Delta
Type of shared information	Transactional, operational, strategic	Transactional, operational, strategic	Transactional	Transactional
Frequency of information sharing	Daily	Daily	Daily	Daily
Decision making	No collaborative decision making	Collaborative decision making	No collaborative decision making	No collaborative decision making

Table 4 – Comparison of the Advanced Technical Supply Chain Governance Dimension

4.3 Relational supply chain governance

The relational supply chain governance analysis focuses on the importance of trust, bargaining power and long-term relationships on information sharing (see Table 5). Our data suggest that long-term relationship within the supply chains from Alpha and Beta foster strategic information sharing, where strategic information sharing is characterized, i.e., by the access to inventory data and point-of-sales data.

"[…] you have Point-of-Sales data as reference (for forecasting) from the last periods that kind of information sharing happens for sure." (Beta, paragraph 36)

Furthermore, we found that the type of shared information varies, depending on the duration of the relationship. Beta mentioned strategic information sharing with long-term suppliers, while they share only transactional information with one-time suppliers.

"There are some specific suppliers […]. This (information sharing) depends on the suppliers and its clusters." (Beta, paragraph 94)

In accordance with the finding from Dyer and Singh (1998), Alpha and Beta stated their interest in having fewer suppliers and invest in long-term relationships in order to mutually create value. From an information sharing perspective, strategic information is shared and enables supply chain members to increase flexibility and commonly improve lead times

"[…] in a volatile environment […] flexibility is important […] we have different categories of suppliers […] having flexible suppliers who are able to increase their production on short notice […]." Firm Beta, paragraph 76); "[…] certain processes (with long-term suppliers) can be adjusted towards reducing lead-times by 66% from 90 to 30 days." (Beta, paragraph 181)"

Moreover, the relationship from Gamma and Delta with their suppliers can be differentiated from a bargaining power perspective. Delta is forced by its supplier to order a minimum quantity to get raw material supplied, while firm Gamma can determine the details of the order, i.e., order quantity and delivery date.

"[…] the suppliers say if you want to have the drapery in your color […] then you have to buy a minimum order quantity." (Delta, paragraph No. 176)

However, in a weak buyer-strong supplier relationship the information sharing behaviors are not defined by the stronger partner. The suppliers from firm Delta are able to use their bargaining power to require minimum order quantities; however they are not able to influence the level of shared information from its customer. Firm Alpha, Beta and Gamma are in strong buyer-weak supplier relationships, and they determine the patterns of information sharing in the supply chain. This reflects that the level of shared information in a strong buyer-weak supplier relationship is governed by the stronger partner.

"We have defined order minimums and mechanism to work efficiently." (Beta, paragraph No. 267)

Despite that, Gamma and Delta are not interested in long-term relationships and do not consider sharing operational or strategic information. We believe that this approach is manifested within the firms´ principles and culture.

"It is always dangerous […] to allow external firms to look into it (information). […] This is not good." (Delta, paragraph 112, 116, 118, 120)

Relational Supply chain governance	**Alpha**	**Beta**	**Gamma**	**Delta**
Trust	Trust with long-term suppliers	Trust with long-term suppliers	No trust	No trust
Relationships length	Long-term and short-term relationships	Long-term and short-term relationships	Short-term relationships	Short-term relationships
Bargaining power	Strong buyer	Strong buyer	Strong buyer	Weak buyer

Table 5 – Comparison of the Relational Supply Chain Governance Dimension

5 Discussion

Based on evidence from the four cases, this study shows that the way information is shared between supply chain partners varies thus indicating that firms differ in terms of their supply chain governance competencies. It is important to note that for relational supply chain governance, bargaining power aspects and incentive structures are important, and in particular, incentives need to be aligned to enable information sharing. This finding helps explain the conflicting results regarding the relationship between information sharing and performance in previous studies examining supply chains only from a technical perspective (e.g., Ketchen & Hult, 2007; Prokesch, 2010). By ignoring the relational dimension of supply chain governance, and focusing only on the technical dimension, previous studies showed conflicting findings when two firms were similar in their technical supply chain governance.

Our findings are also consistent with those of previous researchers who have argued that user acceptance of (inter-organizational) information systems is crucial (Davis, 1989). While information systems can be seen as an enabler for information sharing efficiency (Premkumar, 2000), its usage is not a sufficient condition for sharing information. Our data suggests the importance of supply chain knowledge on information sharing. More specifically, the knowledge about information sharing processes, its possibilities and the positive impact of information sharing on supply chain performance differs among supply chain members. We found that firms share transactional information on a daily basis, while operational and strategic information sharing depends on the (collaborative) approach of the stronger firm (e.g., Argyres & Liebeskind, 1999).

Although Alpha and Beta are the stronger partners, their information sharing behaviors differ. Beta mutually shares operational and strategic information with trustworthy long-term suppliers, whereas no information is shared with the other suppliers. Beta has also established a collaborative planning process for its long-term suppliers and institutionalized rules and norms. Interestingly, Alpha unilaterally shares operational and strategic information, although they have no interest in a collaborative planning approach. In our opinion, this can result in unaligned supply chain governance structures that negatively affect the supply chain performance. By sharing information without the design and alignment of collaborative processes, firms are not able to realize the benefits of mutual information sharing.

In contrast Gamma and Delta share no information. Gamma has no interest in a collaborative approach or long-term relationships, but due to its bargaining power Gamma can oblige the suppliers to comply with the given requirements. Despite its weak bargaining power, Delta is neither interested in a collaborative approach, nor in long-term relationships with its suppliers, therefore resulting in no information sharing. Although suppliers have a stronger bargaining power position compared to Delta, the suppliers do not demand upstream strategic information sharing, which can be considered as expectations for future business (Heide & Miner, 1992).

The results of the analysis indicate that supply chain governance competencies can determine mutual information sharing. More specifically, relational supply chain governance delineated by bargaining power and socio-political factors such as trust influence information sharing. We employ a more nuanced view towards supply chain governance by going beyond a primarily technical focus of analysis adopted in previous research. Since previous studies often focus on only the technical dimension, their arguments may be incomplete, and further research on understanding patterns of information sharing from a relational dimension is needed.

The four cases enabled us to explore different information sharing behaviors among supply chain members. Furthermore, the case studies offer insights that clarify the in-consistencies emerging from previous research on the information sharing processes. We found that technical supply chain governance dimension has no influence on the decision to share information (or not), but rather influenced the efficiency of information sharing. We identified supply chain knowledge, trust and bargaining power as important aspects that influence information sharing behavior. Furthermore, we found that bargaining power of firms is used to manage and govern the information sharing strategy for supply chains. Accordingly, we propose

- *Proposition 1:* In supply chain relationships, irrespective of bargaining power differences, there is no information sharing without aligned supply chain governance mechanisms.
- *Proposition 2:* In a strong–weak relationship, the stronger partner dictates the information sharing strategies.
- *Proposition 3:* In a strong-weak relationship, aligned supply chain governance mechanisms results in mutual information sharing.

6 Limitations

The contribution of this paper should be interpreted in the face of its limitations. First, only one major factor – supply chain governance has been used to analyze and explain differences in information sharing in supply chains (e.g., H. L. Lee et al., 1997; Sunil Mithas et al., 2011). Future research could consider cultural factors, inter-firm learning processes and supply-chain specific investments to explain differences in information sharing (e.g., Doz, 1996; Dyer & Nobeoka, 2000). Second, we found that bargaining power is used differently in supply chains to establish information sharing processes depending on the position of the firm in the network. This could be an interesting direction for future studies to explore under what conditions the influence of bargaining power would have an impact on information sharing (Nair et al., 2011). Further, all the cases analyzed are from the retail sector. While this allows us to control for cross-industry variations, the findings from this study should be extended with caution to other industries. An exploration of supply chains in other industries could be used to validate and fine-tune the propositions. This is especially true as case studies do not allow researchers to control events and might capture only contemporary events (Yin, 2009). Finally, it could be interesting and worthwhile to investigate information sharing processes using other theoretical perspectives such as game theory or a community learning perspective (e.g., Ketchen & Hult, 2007; Parkhe, 1993; Prokesch, 2010; Straub et al., 2004).

7 Conclusion

This research contributes to theory by analyzing the supply chain governance competencies of firms in fashion retail supply chains using exploratory case studies to explain differences in information sharing behavior. Our findings can allow practitioners to improve their understanding of information sharing and develop information sharing strategies and guidelines for managing, governing and improving information sharing. More specifically, we explain different information sharing strategies and illustrate the positive relation of collaborative planning solutions and trust (i.e., relational factors) on mutual information sharing. Practitioners should align incentives, to optimize overall supply chain performance and compete through the formation of alliances.

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Publication 3

Interdependencies between antecedents on information sharing in supply chains: A concept-centric literature review

Title	Interdependencies between antecedents on information sharing in supply chains: A concept-centric literature review	
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Abstract

The purpose of this paper is to analyse interdependencies between the antecedents on information sharing in supply chains by conducting a concept-centric literature review. In the course of the review, we analyse qualitative and quantitative publications, reveal key antecedents, and investigate interdependencies between them. We summarize the findings to provide a comprehensive view of the factors that influence information sharing in supply chains. In addition, we analyse and describe the impact of identified antecedents on information sharing. The analysis reveals research gaps in the qualitative research on organizational, managerial, and cultural aspects, as well as quantitative research on economic aspects of information sharing.

Individual contribution from Tobias Engel: My contribution includes the definition of the research questions and the research goal. While the search for literature was done by my colleagues, I lead the analysis of the results including the discussion of the results. The writing of the article was done commonly by using the "review" mode. Further, I did the final correction of the text. Within the 2nd review round, the comments were discussed and will be addressed by me. Submission of the 2nd version is planned for June/July 2015.

1 Introduction

Intensification of information sharing has become crucial for supply chain collaboration (Ghosh & Fedorowicz, 2008; Wadhwa, Mishra, Chan, & Ducq, 2010), in most cases resulting in performance improvements and increases in revenues (Moberg, Cutler, Gross, & Speh, 2002). However, effectiveness of information sharing is determined by many antecedents (B.-C. Lee, Kim, Hong, & Lee, 2010). Firms can share transactional, operational, and/or strategic data with their upstream and downstream partners (G. Q. Huang, Lau, & Mak, 2003). As previous studies have shown, most successful supply chain alliance members exchange strategic information (Straub, Rai, & Klein, 2004). For example, Walmart provides its suppliers with point-of-sales data to generate better demand forecasts, resulting in an improved firm performance (H. L. Lee, So, & Tang, 2000). Further improvements include an increase of inventory rotation and shortened time-to-market (J. Li, Sikora, Shaw, & Woo Tan, 2006). However, in practice it is often observed that firms share solely transactional information and avoid strategic information sharing (Senge & Prokesch, 2010). Hence, it is important to understand antecedents that impact decisions about kind of information that has to be shared, with whom it needs to be shared, and when is the best time to share it.

Existing research on the antecedents on information sharing lacks a synthesized understanding of the factors their interrelations with each other. Another shortcoming of existing studies is that they do not provide analysis of the quantitative body of knowledge in order to give a comprehensive description of antecedents. Therefore, this paper aims to investigate antecedents on information sharing in supply chains guided by the following research questions: What are the main antecedents influencing information sharing in supply chains, how do the antecedents interrelate with each other, and what are the effects of the identified antecedents on each other and on information sharing?

The remaining part of the paper is structured as follows: the next section includes a detailed description of the research design. Section 3 describes the findings of the literature review and provides critical assessment of the factors that impact information sharing. The next section contains discussion on interrelationships between antecedents and summary of the outcomes of qualitative research. Section 5 is concerned with limitations of the research and contains suggestions for the future development of the topic. Section 6 provides overall conclusions based on the data that has been gathered and analysed.

2 Research Design

In the course of the concept-centric literature review, academic papers from five publication databases were reviewed. These include IEEE Explore, ACM Digital Library, Science Direct, Emerald Insight and EBSCO Host. Additionally, we used Google Scholar. Thereby, the results covered publications from leading journals in the field of supply chain management, business informatics, organization and management science, information management, and decision support systems. Further, we included proceedings of major conferences in the related fields. In addition, we conducted a backward and forward search as proposed by Webster and Watson (2002).

As the first step, a keyword search was used to identify the relevant papers. The set of keywords included “supply chain”, “information sharing”, “knowledge sharing”, “collaboration”, “alliances”, “factors”, “antecedents”, “barriers” and combinations of these words. In the review process, we identified 450 publications, followed by two subsequent screening stages. The first screening included analysis of each article’s title, keywords and abstract in order to determine publications relevant to supply chain collaboration and its information sharing constituent. In the course of the second screening stage 161 articles were analysed. During this stage we considered the full text of each publication and excluded another 95 articles due to low relevance to the topic, insufficient research value, incompliance with the purposes of the review, or poor quality. Additionally, we enriched the resulting article set through backward and forward search. In total, 75 publications were examined: 39 qualitative studies and 36 quantitative studies (Figure 1).

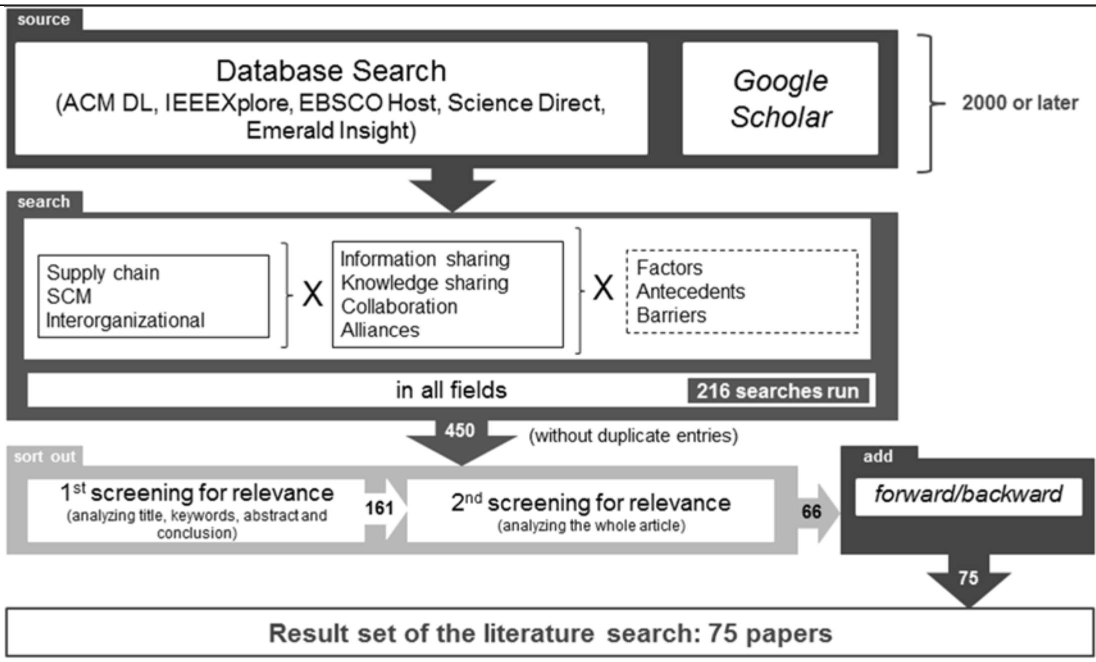

Figure: 1 – Quantitative description of the research stages

3 Antecedents and theories in the field of SCM

In the following section, we analyse identified antecedents on information sharing by summarizing the quantitative and qualitative body of knowledge that was used to explain supply chain relationships and their antecedents on information sharing.

3.1 Trust

Sharing of strategic and operational information bears a chance of being misused by a partner in their own interest (Klein & Rai, 2009). The qualitative research argues that trust between organizations involved in a supply chain relationship is viewed by many researchers as the central issue determining information sharing (Bongsug, HsiuJu Rebecca, & Chwen, 2005; Gulati & Nickerson, 2008; Handfield & Bechtel, 2002; Hu, Xiao, Xie, & Saraf, 2011). Complying with the interests of other supply chain partners provides an effective work relationship and reduces the risk of opportunistic behaviour accounting for a long-term cooperation (Paulraj, Lado, & Chen, 2008).

Table 1 summarizes the relationships that were tested within the found quantitative studies, indicating the direction and significance of the determinants obtained by different researchers. Here we can see a clear positive relationship between trust and strategic and operational information sharing, supported by eleven studies. Positive influence of trust on relationship and commitment was also supported in three cases. The negative relationship to costs was proven by one study with a high level of significance. Relationship between trust and information quality was not so clear. The study by S. Li, Ragu-Nathan, Ragu-Nathan, and Subba Rao (2006) showed a high significance of relationship between these factors, however the publication by Jiang and Li (2010) did not find it significant, although positive. Relationship between trust and technical competence as well as between trust and governance were also proved to be positive and fairly significant.

Independent	Dependent	Citation	Significance
Trust	Technical competence	(Lippert, 2007)	+*
	Governance	(Gulati & Nickerson, 2008)	+**
	Costs	(Zaheer, McEvily, & Perrone, 1998)	-***
	Information quality	(S. Li & Lin, 2006)	+***
	Information quality	(Jiang & Li, 2010)	+
	Relationship and commitment	(Kwon & Suh, 2004; M.-Y. Wu, Weng, & Huang, 2012)	+***
	Relationship and commitment	(Nyaga, Whipple, & Lynch, 2010)	+**
	Operational information sharing	(B.-C. Lee et al., 2010)	+**
	Strategic information sharing	(Klein & Rai, 2009; Youn, Yang, Hong, & Park, 2013)	+***
	Strategic information sharing	(B.-C. Lee et al., 2010)	+**
	Information sharing	(Chen, Lin, & Yen, 2014; Hu et al., 2011; Jiang & Li, 2010; S. Li & Lin, 2006; Liao, Ma, Lee, & Ke, 2011; I.-L. Wu, Chuang, & Hsu, 2014; Yin & Zhao, 2008)	+***
	Information sharing	(Cai, Jun, & Yang, 2010)	+**
***p<0.01, **p<0.05, *p<0.1			

Table 1 – Summary of quantitative studies on trust

3.2 Information quality

Quality of information refers to a number of characteristics against which information can be measured in order to determine if it meets the needs of an organization or a supply chain partner. The study by Goswami, Engel, and Krcmar (2013) defines information quality using six characteristics: accuracy, availability, compatibility, completeness, confidentiality, and timeliness.

As qualitative research states, the aspects such as type of information shared as well as when and with whom it is shared greatly influences the desired quality of information (Ramayah &

Omar, 2010). Quality also depends on trust and shared vision between partners and is negatively influenced by supplier uncertainty (Krishnan, Martin, & Noorderhaven, 2006). On the other hand, impact of buyer uncertainty, technology uncertainty, commitment of supply chain partners and IT enablers is considered to be rather low by some researchers (S. Li et al., 2006).

The relationship between higher information quality and strategic and operational information sharing was shown to be significant by four out of five discovered quantitative studies. A fairly high level of significance of information quality for other antecedents such as governance and incentive alignment was determined in the study by Wiengarten, Humphreys, Cao, Fynes, and McKittrick (2010). These findings are summarized in Table 2.

Independent	Dependent	Citation	Significance
Information quality	Governance	(Wiengarten et al., 2010)	+**
	Incentive alignment	(Wiengarten et al., 2010)	+**
	Strategic information sharing	(B.-C. Lee et al., 2010; Moberg et al., 2002)	+**
	Strategic information sharing	(Ramayah & Omar, 2010)	+
	Operational information sharing	(B.-C. Lee et al., 2010)	+
	Information sharing	(Wiengarten et al., 2010; Yin & Zhao, 2008)	+***
***p<0.01, **p<0.05, *p<0.1			

Table 2 – Summary of quantitative studies on information quality

3.3 Technical competence

Considering the fact that information technology allows to collect, process, store, and transfer vast amounts of data in a matter of seconds, it has expectedly become a vital determinant of information sharing in supply chain collaboration (Hong & Fuchun, 2010; Smith, Watson, Baker, & Pokorski, 2007). Therefore, qualitative research proves that lack of inter-organizational technical resources and competencies is of the decisive barriers to information sharing (Nagy, 2006).

Positive relationship between technical competence and information sharing has been proved to be significant by eight quantitative studies. Technical competence also strongly influences trust, which as has been demonstrated by three research studies. In regard to relationship between technical competence and information quality, the significance was not as clear. While study by Jiang and Li (2010) suggested high significance of the positive relationship, the publication by S. Li et al. (2006) found it positive, but insignificant (Table 3).

Independent	Dependent	Citation	Significance
Technical competence	Trust	(Hu et al., 2011; Wang, Fu, & Wang, 2006)	+***
	Trust	(Carr & Smeltzer, 2002)	+**
	Information quality	(Jiang & Li, 2010)	+***
	Information quality	(S. Li & Lin, 2006)	+
	Operational information sharing	(B.-C. Lee et al., 2010)	+**

	Strategic information sharing	(Klein & Rai, 2009)	+***
	Strategic information sharing	(B.-C. Lee et al., 2010)	+**
	Information sharing	(Patnayakuni, Rai, & Seth, 2006a; Paulraj et al., 2008; Rajaguru & Matanda, 2013)	+***
	Information sharing	(Carr & Smeltzer, 2002; Jiang & Li, 2010; Sanders & Premus, 2005)	+**
***p<0.01, **p<0.05, *p<0.1			

Table 3 – Summary of quantitative studies on technical competence

3.4 Governance

Performance of supply chains largely depends on coordination of material and information flow (Sahay, 2003). In order to reduce risks and ensure successful informational integration of supply chains, partners need to establish a number of key relationships, which among the other tasks will guide and control sharing practices and processes. In other words, partners have to institute mutual governance in order to reduce possibilities of opportunism and establish common structures that negotiate decisions to the benefit of both sides and control execution of these decisions. Joint governance thereby is essential to ensure that ongoing cooperation between organizations can be sustained (Ghosh & Fedorowicz, 2008; Kyung Kyu, Ho, & Young Jin, 2011).

The quantitative research investigating relationships between governance and other factors was found to be rather scarce. We have discovered three references of significant relationship between governance and information sharing and one reference of positive but insignificant connection between governance and relationship and commitment (Table 4).

Independent	Dependent	Citation	Significance
Governance	Relationship and commitment	(Nyaga et al., 2010)	+
	Operational information sharing	(Wiengarten et al., 2010)	+**
	Information sharing	(Müller & Gaudig, 2011; Paulraj et al., 2008)	+***
***p<0.01, **p<0.05, *p<0.1			

Table 4 – Summary of quantitative studies on governance

3.5 Costs and overheads

As stated by the qualitative research, implementation of information sharing in supply chains almost inevitably incurs additional costs, associated with acquiring new technology, expertise and reengineering of existing processes (Hong & Fuchun, 2010; Qi & Qiong, 2008). Diversity in available products for supply chain integration and information sharing systems sometimes also drives the costs up. As participants using different technical platforms join an information sharing network, they consequently increase complexity and information flow intensity (B. Huang & Iravani, 2005). All of above mentioned factors influence the end decisions about information sharing implementation.

No significant relationship between overall costs and information sharing has been discovered in the quantitative literature. The study by Madlberger (2008) asserts that costs do not influence either operational or strategic information sharing (Table 5).

Independent	Dependent	Citation	Significance
Costs and overhead	Operational information sharing	(Madlberger, 2008)	-
	Strategic information sharing	(Madlberger, 2008)	+
***p<0.01, **p<0.05, *p<0.1			

Table 5 – Summary of quantitative studies on governance

3.6 Incentive alignment

To ensure productive functioning of information sharing, businesses within supply chains require clear goals and effective collaboration and cooperation, which in turn needs to be supported by equal sharing of risks, responsibilities and rewards, derived from the common activities (Soosay, Hyland, & Ferrer, 2008). An incentive distribution scheme is usually highly desired in order to ensure clear rules that are to be followed by all members of supply chains. Some researchers argue that explicit contracting as an instrument of governance and alignment of incentives is often a good way to regulate information sharing obligations among firms to ensure fair treatment of both partners (Ha & Shilu, 2008; Mishra, Raghunathan, & Xiaohang, 2007). Others state that if a high level of trust exists between organizations, then formal incentive alignment procedures can be omitted (Handfield & Bechtel, 2002; Klein & Rai, 2009).

Fair alignment of incentives has a positive influence on information sharing. The significance of this relationship has been shown by five studies. Additionally, the research by S. Li et al. (2006) shows a significant positive relationship between alignment of incentives and information quality (Table 6).

Independent	Dependent	Citation	Significance
Incentive Alignment	Information quality	(S. Li & Lin, 2006)	+***
	Information sharing	(Schloetzer, 2012)	+***
	Information sharing	(S. Li & Lin, 2006)	+**
	Information sharing	(Müller & Gaudig, 2011)	+*
	Operational information sharing	(B.-C. Lee et al., 2010; Wiengarten et al., 2010)	+**
	Strategic information sharing	(B.-C. Lee et al., 2010)	+**
***p<0.01, **p<0.05, *p<0.1			

Table 6 – Summary of quantitative studies on governance

3.7 Organizational structure and culture

When implementing information sharing processes and policies, organizations often encounter difficulties related to cultural and psychological particularities of personnel, as well as hindrances of organizational and political nature (Fawcett, Magnan, & McCarter, 2008; S. Li et al., 2006). Unclear policies, lack of formalized processes, loose and incompatible organizational structures, cultural discrepancies in organizations engaged in supply chain activities can have a negative impact on the overall functioning efficiency and particularly on information sharing aspect of supply chain collaboration. Examples of these could be resistance to change and reluctance to revealing strategically important information to other supply chain partners by the staff and management as well as unclear separation of powers and responsibility domains (Ramayah & Omar, 2010).

Clear, stable and compatible organizational structures are important as they serve as a basis for development of information sharing and promote mutual willingness of the organizations to collaborate with one another (Fawcett, Wallin, Allred, & Magnan, 2009).

As we can see from the results of the review of quantitative studies, summarized in Table 7, the influence of organizational structure and culture on information sharing is not fully clear. The study by B.-C. Lee et al. (2010) shows rather low significance of the relationship to strategic information sharing, whereas other studies demonstrate the existence of strong positive relationship to information sharing. The research by Wang et al. (2006) supports the hypothesis about the existence of significant positive relationship between organizational structure and culture and trust.

Independent	Dependent	Citation	Significance
Organizational structure and culture	Trust	(Wang et al., 2006)	+**
	Operational information sharing	(B.-C. Lee et al., 2010)	+**
	Strategic information sharing	(B.-C. Lee et al., 2010)	+
	Strategic information sharing	(Youn et al., 2013)	+**
	Information sharing	(Jiang & Li, 2010; Rajaguru & Matanda, 2013; Saleh, Ali, & Mavondo, 2014)	+***
***p<0.01, **p<0.05, *p<0.1			

Table 7 – Summary of quantitative studies on organizational structure and culture

3.8 Management support

In the modern interconnected business world a company is unlikely to achieve high performance unless its inter-organizational processes and activities are effectively managed (Ramayah & Omar, 2010). As stated by the qualitative research, organizations need to maintain close contact with supply chain partners not only for exchange of transactional and operational information, but in order to understand goals of their partners and communicate own objectives. Top management can facilitate overall informational integration by providing vision, guidance and support for the related initiatives (B.-C. Lee et al., 2010; Mentzer et al., 2001; Youn et al., 2013).

The positive relationship between management support and operational and strategic information sharing has been proved to be significant by six quantitative studies. The hypothesis about a relationship between top management support and information quality was supported only by one study with a low level of significance of the relationship (Table 8).

Independent	Dependent	Citation	Significance
Management support	Information quality	(S. Li & Lin, 2006)	+*
	Information quality	(Jiang & Li, 2010)	+
	Operational information sharing	(Youn et al., 2013)	+**

	Operational information sharing	(B.-C. Lee et al., 2010)	+
	Strategic information sharing	(Youn et al., 2013)	+***
	Strategic information sharing	(B.-C. Lee et al., 2010; Madlberger, 2008)	+**
	Information sharing	(Jiang & Li, 2010; Paulraj et al., 2008)	+***
	Information sharing	(S. Li & Lin, 2006)	+**
***p<0.01, **p<0.05, *p<0.1			

Table 8 – Summary of quantitative studies on management support

3.9 Relationship and commitment

As provided by qualitative research, essential factors for development of information sharing between supply chain partners are relationship, commitment, and interdependence. Interdependence is defined as the extent to which supply chain partners believe that their business relationship is necessary. Commitment refers to a firms' need to maintain tight cooperation with a partner in order to achieve its goals (Kyung Kyu et al., 2011). It is manifested in willingness of organizations to negotiate, share key information and participate in joint planning initiatives (Bongsug et al., 2005).

Table 9 summarizes the quantitative research findings for relationship and commitment. Nine out of ten studies show a significant relationship between commitment and information sharing and two studies support the hypothesis of interrelationship between commitment and trust. The influence of relationship and commitment on information quality has been proven to have low significance.

Independent	Dependent	Citation	Significance
Relationship and commitment	Trust	(Chen et al., 2014; Nyaga et al., 2010)	+***
	Information quality	(S. Li & Lin, 2006)	+*
	Information quality	(Jiang & Li, 2010)	+
	Operational information sharing	(B.-C. Lee et al., 2010)	-
	Strategic information sharing	(B.-C. Lee et al., 2010; Moberg et al., 2002)	+**
	Information sharing	(Patnayakuni, Rai, & Seth, 2006b; Schloetzer, 2012; I.-L. Wu et al., 2014; Zhao, Huo, Selen, & Yeung, 2011)	+***
	Information sharing	(Cheng, Chen, & Chen, 2013; Hernández-Espallardo, Rodríguez-Orejuela, & Sánchez-Pérez, 2010; Yigitbasioglu, 2010)	+**
	Information sharing	(Jiang & Li, 2010)	+*
***p<0.01, **p<0.05, *p<0.1			

Table 9 – Summary of quantitative studies on relationship and commitment

4 Discussion: comprehensive view of the results

Table 10 sums up the findings of the literature review, showing interrelationships between the antecedents. The comprehensive view lists the numbers of discovered qualitative and quantitative publications related to a particular relationship, as well as notes how many of the quantitative publications have proven the relationship to be significant. The results provide a comprehensive description of antecedents that are found within supply chain relationships and offer an overview of scientific experiments that have been conducted within the literature, as well as the outcomes of these experiments. Results were considered to be significant if the p-value of the described relationship was less than 0,1 ($p<0,1$). For example, in the case of influence of trust (independent variable) on overall information sharing (dependent variable), we can see that 16 qualitative studies were found, that emphasize on existence of such dependence. Apart from that, 11 quantitative studies have been found that test this hypothesis. All of these 11 experiments have proved the relationship to be positive and significant, as is marked in the third row of the corresponding table entry (+11).

		Dependent variable										
		Trust	**Information quality**	**Technical competence**	**Governance**	**Costs**	**Incentive alignment**	**Organizational structure & culture**	**Management support**	**Relationship & commitment**	**Information sharing**	**Categories of publications**
Independent variable	**Trust**		-	1	3	-	1	-	-	3	16	Qualitative
		X	2	1	1	1	-	-	-	3	11	Quantitative
			+1	+1	+1	-1	-	-	-	+3	+11	Significant
	Information quality	-		-	-	-	-	-	-	1	7	Qualitative
		-	X	-	1	-	1	-	-	-	5	Quantitative
		-		-	+1	-	+1	-	-	-	+4	Significant
	Technical competence	1	-		1	3	-	1	-	1	19	Qualitative
		3	2	X	-	-	-	-	-	-	9	Quantitative
		+3	+1		-	-	-	-	-	-	+8	Significant
	Governance	1	-	-		1	-	-	-	-	6	Qualitative
		-	-	-	X	-	-	-	-	1	3	Quantitative
		-	-	-		-	-	-	-	0	+3	Significant
	Costs	-	-	1	-		-	-	-	1	12	Qualitative
		-	-	-	-	X	-	-	-	-	1	Quantitative
		-	-	-	-		-	-	-	-	0	Significant
	Incentive alignment	1	-	1	-	-		-	-	-	9	Qualitative
		-	1	1	-	-	X	-	-	-	5	Quantitative
		-	+1	-	-	-		-	-	-	+5	Significant
	Organizational structure & culture	-	-	1	-	-	-		1	-	8	Qualitative
		1	-	-	-	-	-	X	-	-	5	Quantitative
		+1	-	-	-	-	-		-	-	+5	Significant
	Management support	-	-	-	-	-	-	-		-	4	Qualitative
		-	2	-	-	-	-	-	X	-	6	Quantitative
		-	+1	-	-	-	-	-		-	+6	Relationship
	Relationship & commitment	4	-	1	-	-	1	-	-		11	Qualitative
		2	2	1	-	-	-	-	-	X	10	Quantitative
		+2	+1	-	-	-	-	-	-		+9	Relationship

Table 10 – Comprehensive overview of the results

Based on these results, we can state that trust, technical competence, and relationship and commitment are the most thoroughly researched antecedents on information sharing. On the other hand, the influence of management support, governance, and overall costs on the intensity of information sharing is not yet fully explored. Concerning the quantitative research, we can state that apart from investigating the influence of each particular antecedent on the overall information sharing effectiveness, the research has been found to be rather scarce. Specifically, we have discovered very few publications that considered incentive alignment, organizational structure, and culture and management support as dependent constructs.

One point that was discovered in the course of the study is the existence of a significant inequality between the amounts of quantitative and qualitative research concerning such antecedents as overall costs and technical competence. These are the areas where the need for experimental testing of hypotheses is still high.

Further important fact that came out as the result of our research is the contradiction in findings concerning relationships that consider information quality as a dependent variable. Here we can see that influence on quality of the shared information by such antecedents as trust, technical competence, organizational culture and structure, relationship and commitment and management support is strongly supported by some publications, while being rejected by others. This gives a clear signal that further investigation of this particular antecedent is needed.

As of theoretical explanation of the relationships between antecedents on information sharing in supply chains, researchers usually chose one theoretical perspective as predominant and then complimented it with one or several other theoretical perspectives. Hence, many researchers focused on using a resource-based view and transactional perspective, while social theory, agency theory, and further theories were used seldom (Carter et al., 2014). However, the used theories such as the resource-based view or transaction cost theory focus either on internal processes of firms or on dyadic relationships, and not on networks or multiple node relationships (Halldorsson, Kotzab, Mikkola, & Skjøtt-Larsen, 2007). In consequence, research within the field of supply chain management, especially for antecedents on information sharing, misses a rich and robust theoretical grounding (Carter et al., 2014).

For example, the resource-based view focuses on sources for creating competitive advantage for a firm (Agan, 2012) and lies primarily in the application of a combination of tangible and intangible resources at the organizations' disposal (Wernerfelt, 1984). The resource-based view on the determinants of information sharing was adopted by twelve articles. The major drawback of this theory, however is, that it only considers information sharing from a firm's own perspective, without emphasizing on the necessity of creating benefit for all supply chain participants (Rajaguru & Matanda, 2013).

Transaction cost theory in supply chain management focuses on the economic aspects of supply chain collaboration and attempts to evaluate how actions performed by the partners affect the costs of economic exchange. In our case, costs and risks involved in collaboration and information exchange are the central aspects (Yigitbasioglu, 2010). One of the limitations of the transaction cost theory is that it does not consider the interdependencies and relationships between modern businesses (Jraisat, Gotsi, & Bourlakis, 2013). The transaction cost theory is used twenty two times to analyse factors such as alignment of incentives, technical capabilities, or overall costs.

The agency theory separates firms into a stronger supply chain partner (buyer/agent) and the weaker partner (supplier/principal). The theory can be applied to explain factors like management support, incentive alignment, governance, or organizational culture (Madlberger, 2008; Nagy, 2006). However, in the case of an equal relationship between supply chain partners, the possibilities for application of the theory are limited; explaining why only six papers emphasized on this perspective (Bongsug et al., 2005; Kyung Kyu et al., 2011).

Social and socio-political theories argue that antecedents offered by transaction cost theory are not sufficient for understanding what affects firms' decision to enter into a relationship with other firms and share knowledge with them (Ke & Wei, 2005). For example, network theory is usually applied in supply chain management to map activities, actors and resources to model interdependencies in supply chain relationships (Halldorsson et al., 2007). Factors such as trust, relationship, commitment, or organizational culture are often analysed antecedents. However, as social theories are concerned with intangible or unquantifiable antecedents, its sole usage is limited due to missing attention of economic effects on supply chain relationships; therefore it is often complimented with transaction cost theory (Jraisat et al., 2013; Patnayakuni et al., 2006a). Among the identified publications, thirteen scholars have used social, socio-political, and socio-economic theories in their research.

Our findings provide evidence, that information sharing and its antecedents have in most cases been analysed from a single perspective, limiting the research focus on one or two antecedents, and concentrating on performance and not on antecedents on information sharing themselves. Further, sometimes the obtained results were contradictory. While a positive effect of information sharing on (either firm or supply chain) performance has been verified, there is no explanation on why firms avoid sharing information. Our results allow clustering the antecedents and providing first insights on their importance. However, we can state, that further research needs to identify an appropriate theoretical approach to organize the antecedents (based on their importance for information sharing), and to analyse on how antecedents affect changes in information sharing in supply chain relationships.

5 Limitations and future research

Among some of the limitations of the literature review conducted within this paper, we can name the amount of chosen publication databases and used publication selection and filtering criteria. Also, in the course of our research we only considered quantitative studies based on data obtained from real-world settings, excluding the publications devoted to development of mathematical models and simulations of the processes that affect information sharing. The found quantitative publications were of reasonably high quality and results across the studies were in most cases consistent. Therefore, we believe that the drawn conclusions correctly represent the state-of-the-art in research on antecedents on information sharing in supply chains.

Further, the findings of the literature review provide us with points, which can be investigated in the course of future qualitative and quantitative exploration of the topic. For example, the role of management support, organizational culture, and structure has not yet been thoroughly studied in comparison with the other antecedents. The impact of cost on the efficiency and effectiveness of information sharing also needs to be tested.

6 Conclusion

The aim of this paper is to explore the current state of research in the field of information sharing in supply chains, focusing specifically on the antecedents on information sharing, and interrelations between influencing factors. The effect and significance of these relationships, as well as overall impact of each antecedent on information sharing, were investigated by summarizing the outcomes of the quantitative studies. Firms, seeking to collaborate with their supply chains partners need to consider all direct and indirect influence factors. Apart from technical factors, which are often viewed as decisive, there are also relationship, economic, and cultural influences that must be considered. To conclude, the analysis of the publications has shown that research in the area of information sharing antecedents is scarce, and the need for further research and complimentary usage of theories to cover supply chain relationships is high. Further, the literature review demonstrated uneven distribution of researchers' attention to different factors, especially in the area of quantitative research. Relationship-related and technical aspects are better elaborated, whereas organizational, management and economic factors are less researched.

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Publication 4

Variances in Supply Chain Information Sharing: An Analysis based on Incentive Alignment and Game Theory

Title	Variances in Supply Chain Information Sharing: An Analysis based on Incentive Alignment and Game Theory	
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Abstract

There exist significant differences in terms of the amount of information that is shared among various supply chains. Among the various factors that affect performance and information sharing, bargaining power of firms and the level of incentive alignment are important considerations for sharing information within supply chains. This research presents a framework for explaining variances in in-formation sharing patterns in supply chain relationships. Drawing from game-theory, the framework is structured along two dimensions – bargaining power and incentive alignment, and postulates how these factors influence information sharing in supply chain relationships. The proposed framework contributes to theory and practice by developing a novel perspective to analyze information sharing in supply chains. The framework will allow practitioners to formulate and evaluate strategies to manage information sharing more effectively within their supply chains.

Individual contribution from Tobias Engel: Within this publication, my main contribution is the idea for the "information sharing framework". Further, we wrote the text mutually (all chapters), and thereby defined how game theory can be used to analyze differences in information sharing behavior among supply chain partners. In consequence, this paper sets the base for Publication 5.

1 Introduction

Better supply chain management initiatives can result in up to 50% drop in inventory levels, almost zero stock-out rates, better revenues and higher net margins (Swink, Golecha, & Richardson, 2010). Firms often rely on information systems to implement new supply chain management initiatives to realize cost savings (Enslow, 2006). Information sharing in supply chains has been recognized as an important factor influencing supply chain performance (Lee, So, & Tang, 2000; Rai, Patnayakuni, & Seth, 2006).

Despite the well-recognized benefits of information sharing and the availability of technological solutions that facilitate the sharing of information within supply chains and networks, firms may still avoid sharing information with their suppliers or buyers (Butner et al., 2010; Kogut & Zander, 1992; Lee & Whang, 2000; Porter & Millar, 1985). Firms may aim for selfish enhancement of their own competencies in order to realize competitive advantage and bargaining power within a relationship (Nair, Narasimhan, & Bendoly, 2011). Furthermore, having access to and control over strategic information allows firms to influence terms and conditions in their own favor (Argyres & Liebeskind, 1999). This results in varying degrees of information sharing among supply chain members, often determined by incentive alignment and differences in bargaining power (Fisher, Hammond, Obermeyer, & Raman, 1994; Patnayakuni, Rai, & Seth, 2006; Straub, Rai, & Klein, 2004). Previous research has explained information sharing behaviors among supply chain members using various theories, like the transaction-cost economics theory, agency theory, and property rights theory. Although the most widely disseminated insights regarding information sharing behavior can be derived from game theory (Straub et al., 2004), game theory has seldom been used as a theoretical perspective in this con-text. Game theory allows the analysis of both magnitude and symmetry of information sharing and further as many dimensions of information sharing as are required for a complete conceptualization and understanding of varying information sharing behavior. Moreover, the effect of differences in bargaining power on information sharing behavior and direct-indirect supply chain members can be assessed in game theory (Straub et al., 2004). However, research applying game theory to explain information sharing behavior among supply chain members is relatively scarce (Ketchen, 2007).

Therefore, we develop a game-theory based framework to explain qualitatively different information sharing patterns in buyer-supplier relationships by using the simplified form of game theory, the prisoners' dilemma game. The framework and the resulting propositions are based on various real cases analyzed and presented in literature. The rest of the paper is organized as follows. The second section provides the theoretical background of information sharing, incentive alignment and game theory in the field of supply chain management. This is followed by a description of the proposed framework. The third section describes the implications limitations and possibilities for future research.

2 Theoretical Development

Collaboration among supply chain members positively affects information sharing, therefore allowing firms to increase their performance (Mithas & Lucas, 2010; Straub et al., 2004).

However, firms may have strategic considerations that prevent them from collaborating (Lee, Padmanabhan, & Whang, 1997). Due to the strong association between information sharing and the bargaining power of firms, this research uses game theory as the theoretical perspective to explain information sharing behavior among supply chain members.

Role of Information Sharing in Supply Chain Management: Supply chain management is facilitated by inter-organizational information sharing (Langley & Holcomb, 1992; Mabert & Venkataramanan, 1998). While transactional information sharing is a necessary condition to streamline the exchange of goods, the sharing of operational information allows firms to establish more efficient supply chain procedures and actions (Seidmann & Sundararajan, 1997). More importantly, strategic information sharing can generate additional rents and focuses on financial information sharing (Gavirneni, Kapuscinski, & Tayur, 1999; Klein & Rai, 2009). Previous research has shown that operational information sharing allows the improvement of supply chain performance (Lee et al., 1997; Rai et al., 2006; Straub et al., 2004).

Despite the recognized benefits of information sharing for supply chain coordination (Klein & Rai, 2009; Lee et al., 1997; Rai et al., 2006), organizations may choose not to share information when it is perceived that information asymmetries can be used as a source of competitive advantage and rent generation, especially when relationships are more opportunistic and/or purely transactional (Argyres & Liebeskind, 1999; Kogut & Zander, 1992; Nair et al., 2011).

Role of Incentive Alignment in Supply Chain Management: Incentive alignment means all supply chain members will gain from cooperation through economic value creation (Agarwal, Croson, & Mahoney, 2010). Previous research has shown that economic incentive alignment is influenced by the level of trust (Gérard P. Cachon & Lariviere, 2001; Klein & Rai, 2009), cultural aspects (Lee & Whang, 2000) and supply chain governance (Godsell, Birtwistle, & van Hoek, 2010; Harland & Knight, 2001). Although supply chain governance often refers to the information management capabilities of firms from a technical perspective, a socio-political perspective emphasizes the social dilemma between cooperation and competition (Zeng, 2003). The bullwhip-effect illustrates an exemplary supply chain problem of firms coping with cooperation and competition as a result of incentive structures, bargaining power and information sharing (Lee et al., 1997).

The dilemma faced by the supply chain partners is whether to maximize their own interest or the interests of the supply chain as a whole. A short term individual partner's self-interested choice, albeit rational, will lead to a failure of a collaborative supply chain, which therefore pose a social dilemma for each of the partners (Dawes, 1980). This may result in rational but uncooperative behavior, shortage gaming (Lee et al., 1997), and threats for firms such as high inventories, stock-out situations or markdown of products (Straub et al., 2004). The presented dilemma stresses the need and importance of incentive alignment to improve supply chain performance (Narayan & Cassidy, 2001). Accordingly, the level of complexity in designing an incentive system is high (Tosi, Katz, & Gomez-Mejia, 1997).

Applying Game Theory to Supply Chain Management: Game theory has been used in the management and strategy literature to explain various aspects of inter-firm actions and behaviors. For instance, the prisoners´ dilemma game was used as a framework to explain cooperation within strategic alliance settings (Parkhe, 1993a, 1993b). It can also be used as a theoretical perspective to examine inter-organizational learning and knowledge sharing (Liu, Ray, & Whinston, 2010). Further, it has been suggested that using a game-theoretic framework for examining inter-organizational relationships will allow researchers to analyze future interactions, communication and performance of supply networks and come up with useful insights regarding them (Heide & Miner, 1992).

Previous research has shown that from a bargaining perspective, the power of a firm in a supply network depends firstly on the product and secondly on the holistic bargaining power of the firm within the industry (Choi & Sethi, 2010; Porter & Millar, 1985). Although the general willingness of firms to engage in supply chain management initiatives can be realistically assumed, firms may focus on (unilaterally) increasing their profits (Ketchen, 2007; Nair et al., 2011). From a supply chain perspective it is necessary to analyze how bargaining power, inter-relational dependencies of supply chain members and further factors influence information sharing and value creation (Ketchen, 2007).

Game theory has previously been used to analyze supply chains, supply networks and its players (Gerard P. Cachon & Netessine, 2004). For instance, Nair et al. (2011) study the influence of investments on bargaining power and inter-firm relationships, while Phelan, Arend, and Seale (2005) examine behavior in alliances with exit options. Given the applicability of game theory in explaining alliance performance and different aspects of supply chain behavior, we believe that a game theory based framework is particularly relevant for explaining information sharing behavior among firms in supply chain relationships.

3 Research Framework

We draw from previously published case studies to examine how game theory (in particular the prisoners' dilemma game) can be used to explain information sharing behavior among firms involved in supply exchanges, and the implications of such information sharing behavior on firm/network performance. Prisoners' dilemma is an example of a game which explains why two individuals might not cooperate even if it is in their best interest to do so. In this game, players can have four different strategies that are mutual cooperation (MC), unilateral cooperation (UC), unilateral defect (UD) and mutual defect (MD). The preference of each player is UD > MC > MD > UC. However, the highest payoff can be obtained through mutual cooperation. We limit our scope of analysis towards operational and strategic information sharing, as they enable supply chain members to compete in the industry and sup-port mutual value creation, while transactional information exchange is a necessity for executing basic supply chain processes in business relationships (Klein & Rai, 2009; Seidmann & Sundararajan, 1997).

We differentiate between mutual information sharing (equivalent to MC), unilateral information sharing (equivalent to UD and UC) and no information sharing (equivalent to MD) as three different information sharing behaviors. When members of the supply chain mutually share transactional, operational, and strategic information, it is referred to as mutual information sharing (MISH). If information is shared by only one of the member firm with either its upstream or downstream partner, it is referred to as unilateral information sharing (UISH). In contrast, no information sharing (NISH) relationships limit information sharing to only transactional information. MISH can be considered the most preferable choice from the perspective of the overall supply chain since it can help both upstream and downstream supply chain members to improve their business processes. To realize a local optimum, UISH is the most preferable choice from the perspective of a firm in the supply chain. No information can result in the lowest firm and supply chain performance. Finally, irrespective of firms´ bargaining power, they may choose to share information due to more uniform distribution of performance gains resulting from such information sharing.

Global supply chain collaboration might lower the actual benefits of supply chain members on an individual level compared to the overall supply chain performance (Ba, Stallaert, & Whinston, 2001), reflecting the need and challenge to collaboratively align the incentives (Tosi et al., 1997). Therefore, incentive alignment can be seen as mandatory task to reward supply chain members for information sharing by distributing risks and costs to ensure a fair distribution of benefits across the network (Narayan & Cassidy, 2001). However, incentives are not always aligned (Zeng, 2003). Therefore, the proposed game-theoretic framework is structured along three dimensions – information sharing, bargaining power of firms and incentive alignment.

3.1 Mutual information sharing

Mutual information sharing includes operational information, i.e., point-of-sales data (Lee & Whang, 2000), and strategic information, i.e., mar-gin structures, marketing strategies (Klein & Rai, 2009). In supply chain relationships, the different level of shared information is determined by incentive alignment and the dependency between firms. While aligning the incentives of all players allows collaborating firms to increase the level of shared information, lack of incentive alignment leads towards a lower level of information sharing (Li & Zhang, 2008). Equal bargaining power allows firms to focus on incentive alignment (Shapiro, 1977) and avoid gaming (e.g., (Liker & Wu, 2000; Simatupang & Sridharan, 2002)). While incentive alignment is effective for ensuring information sharing (Tosi et al., 1997), a stronger bargaining power position allows the stronger firm to distribute the commonly created value according to a pre-defined ratio.

An example of a strong supplier and a strong buyer relationship is the partnership between Procter & Gamble (P&G) and Wal-Mart. The alignment of economic incentives resulted in mutual information sharing and a trustworthy partnership (Kumar, 1996), allowing the implementation of vendor managed inventory. Both firms created higher value in the supply chain. In contrast, the case of three equally strong firms partnering in the UK sheep meat industry (Bailey & Francis, 2008) reveals information asymmetries resulting in medium performance although a collaborative planning, forecasting and replenishment tool was used for information sharing (Fliedner, 2003). All players had the chance to co-operate closely and solve the performance issues within their sup-ply chain. However, this did not happen due to lack of aligned incentives. Toyota as a strong buyer manages its supply chains activities with a co-operative approach by cultivating, institutionalizing, and requesting mutual information sharing among supply chain partners in the Toyota network. Toyota eliminates the notion of proprietary knowledge, allows inter-organizational learning; and engages suppliers in synergistic investments. This behavior can be seen as an investment towards the relationship since the intention is to collaboratively increase the performance of the network as a whole. Therefore the incentives of all members are aligned (Nair et al., 2011). We propose:

P1:Incentive alignment results in mutual information sharing, despite differences in bargaining power.

P2:In case of mutual information sharing, lack of incentive alignment results in a lower level of shared information.

3.2 Unilateral information sharing

In unilateral information sharing relationships, the stronger partner (buyer or sup-plier), specifies the settings, rules and norms for sharing information within the supply chain, and the weaker partner complies with these specifications. It depends on the stronger supply chain partner to use (request) the information egoistically or co-operatively. However, different information sharing behaviors are observed depending on the nature of incentive alignment.

The Dell case (Magretta, 1998) indicates the strong bargaining power of Dell (strong buyer), that allows them to specify, manage and control up-stream supply chain behavior. While operational information is mutually shared, strategic information is unilaterally shared by Dell with its upstream channel partners. There are no explicit attempts towards incentive alignment within the supply chain. However, Dell expects its suppliers to use the shared information to optimize their own supply chain processes in order to realize the monetary expectations and its sharing ratio from the perspective of Dell. The example indicates the influence of incentive alignment towards information sharing and value creation in supply chains. The example also point out the importance of bargaining power and its mediating effect on information sharing, and its impact on the monetary share among supply chain partners. Therefore, we propose:

P3:For a strong–weak relationship, lack of incentive alignment will result in unilateral information sharing.

P4:In a strong–weak relationship, the information sharing strategy is set according to the rules of the stronger partner.

3.3 No information sharing

This relationship is characterized by firms involved in a purely transactional relationship. Equal bargaining power and missing incentive alignment among parties is reflected in their information sharing behavior (Kumar, 1996). Only transactional information necessary for the successful completion of the transaction is shared. The information sharing behavior in this relationship can further be characterized as fearful. Firms fear to loose revenues and therefore limit information sharing onto a transactional level. The availability of other alternative players allows each player to change their transactional partner without any significant transaction cost. Therefore, there is very little motivation among players to align their incentives and to share information in a transactional relationship. How-ever, the L´Oréal case illustrates the positive effect of incentive alignment on in-formation sharing within strong supplier and weak buyer relationships (Senger & Oesterle, 2003). By utilizing a VMI solution, both supply chain members, L´Oréal and its buyer – the drugstore “dm”, improve information visibility by mutually sharing sophisticated operational information. This collaborative approach results in process cost improvements for dm, and a doubled inventory turn rate for L´Oréal. Despite L´Oréal's strong bargaining power in this relationship, this co-operative alignment of incentives reflects strategic expectations regarding future business with dm, and an awareness of the impacts of mutual information sharing.

P5:Irrespective of bargaining power, no information is shared without incentive alignment.

P6:In a strong-weak relationship, reallocating incentives and bargaining power results in mutual information sharing.

Equally strong firms can realize the highest performance for the supply chain by mutually sharing information and aligning incentives (Kumar, 1996); while lack of incentive alignment lowers the performance despite mutual information sharing (Bailey & Francis, 2008). In a strong buyer weak supplier relationship, aligned incentives contribute to mutual information sharing, while in cases where the stronger partner is more interested in improving its own performance unilateral information sharing occurs due to missing incentive alignment (Magretta, 1998).

Based on the above discussion, we develop the information sharing framework (Table 1). The x-axis represents the buyer's information sharing strategies – no information sharing (NISH), and information sharing (ISH). Similarly, the y-axis represents the information sharing strategies of the supplier. The different forms of information sharing represent the discussed information sharing behaviors from previous sections. Therefore, when the buyer follows a strategy of no information sharing, while the supplier has to share information, the supply chain can be characterized as having unilateral information sharing (UISH). Similarly, when both buyer and supplier follow a strategy of sharing information with each other, then the supply chain is characterized as having mutual information sharing (MISH). In case both firms follow a no information strategy, the supply chain can be regarded as having no information sharing (NISH).

		Buyer	
		No Information Sharing	**Information Sharing**
Supplier	**Information sharing**	UISH	MISH
	No information sharing	NISH	UISH

Table 1 – Information sharing framework

4 Discussion and Conclusion

This research contributes to theory by developing an information sharing framework based on existing literature from the fields of supply chain management, information systems and game theory. We present the importance of incentive alignment for information sharing and propose effects of bargaining power on information sharing. Furthermore, this research gives practitioners and researchers the possibility to gain a better understanding why currently 90% of the firms limit their information sharing processes onto a transactional level. Future research should further develop the propositions and test them in empirical settings.

The framework contributes to practice by explaining information management capabilities of firms and their (socio)-political behavior in supply networks. Applying this insight allow firms to use information systems more effectively and increase the depth and quality of information sharing in supply chains. Analyzing different behaviors, like decisions to make supply chain specific investments, cultural factors and similar factors will allow firms to understand information sharing patterns in supply chains. Based on the level of bargaining power and incentive alignment, practitioners can use this new approach to develop actionable strategies and guidelines for managing, governing, and improving information sharing more efficiently.

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Publication 5

Enabling mutual information sharing in supply chains: An explanation on how antecedents influence information sharing behavior

Title	Enabling mutual information sharing in supply chains: An explanation on how antecedents influence information sharing behavior	
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Abstract

Information sharing positively influences supply chain performance. However, information sharing behavior in supply chains significantly differs in terms of the nature and amount of information shared. Among the different factors that affect information sharing, bargaining power of firms, supply chain knowledge, and trust are important considerations for sharing information within supply chains. This research presents a matrix for organizing and explaining antecedents on information sharing in supply chains. Drawing from game theory, the matrix postulates the inter-dependencies of antecedents on information sharing from a buyer and supplier perspective. The propositions are tested using a qualitative two-step research approach that incorporates interviews of supply chain experts and case study research. The contributions of this research are twofold: theoretical development of a matrix that combines important aspects of supply chain management literature with insights from game theory; and empirical validation of the matrix's propositions using qualitative research methods. Our matrix contributes (1) by developing a novel perspective to analyze antecedents on information sharing behavior in supply chains, and (2) linking previous research results on antecedents on information sharing, and (3) allows practitioners to formulate strategies to manage information sharing and supply chain processes more effectively.

Individual contribution from Tobias Engel: My contribution to Publication 5 is the idea for the “information sharing matrix” in order to analyze firms´ information sharing behavior in a game theoretic setting. Further, I wrote all chapters, and addressed comments from my co-authors. As written, the coding has been done jointly, as well as the analysis, and the discussion of the results (originality, practical and theoretical implications). My co-authors helped me to develop the paper and its story, to code the data, to discuss the results, and to improve the writing style of the paper.

1 Introduction

Better supply chain management initiatives can result in higher revenues and net margins (Swink, Golecha, & Richardson, 2010). However, in order to realize such initiatives, firms have to rely on the availability of timely and relevant information. Therefore, information sharing in supply chains has been recognized as an important factor influencing supply chain performance (Barrett & Konsynski, 1982; H. L. Lee, So, & Tang, 2000).

Despite the recognized benefits of information sharing within supply chains and networks, firms may still avoid sharing information with their suppliers or buyers (Fawcett, Osterhaus, Magnan, Brau, & McCarter, 2007; Kampstra, Ashayeri, & Gattorna, 2006; H. L. Lee, Padmanabhan, & Whang, 1997). This is often motivated by the aim for selfish enhancement of their own competencies in order to realize competitive advantage and bargaining power within a relationship (Nair, Narasimhan, & Bendoly, 2011). Furthermore, having access to and control over strategic information allows firms to influence terms and conditions in their own favor (Argyres & Liebeskind, 1999). These complications result in varying degrees of information sharing among supply chain members. Information sharing is often determined by factors such as incentive alignment and differences in bargaining power (Gérard P. Cachon & Lariviere, 2001b; Fisher, Hammond, Obermeyer, & Raman, 1994; Straub, Rai, & Klein, 2004). Several examples from prior literature indicate the existence of differential information sharing behavior among supply chain members resulting from different power relationships (e.g., Dyer & Nobeoka, 2000; Fawcett, Magnan, & McCarter, 2008a; Ferdows, Lewis, & Machuca, 2004). In addition, socio-political factors such as trust, culture, organizational learning, and information management capabilities of firms have been found to influence their information sharing behavior (Strong, Lee and Wang 1997, Lee, Padmanabhan and Whang 1997, Whipple and Frankel 2000).

Multitude factors have been found to influence information sharing in supply chains. However, most research analyzes information sharing either from a transactional perspective or with a focus on information sharing itself and not on antecedents on information sharing (Klein & Rai, 2009). Further, theories such as the resource-based view focus on firms´ strength, without emphasizing on the necessity of creating benefits for all supply chain partners (Wernerfelt, 1984). Moreover, the current research perspective is reflected by applied theories such as the transaction-cost economics theory, agency theory, and property rights theory (Ellram & Cooper, 2014). However, firms still cope with organizational silos and alignment of supply chain strategies, especially from a collaborative information sharing perspective (Marchese & Paramasivam, 2013). In consequence, a new theoretical perspective is needed. Since many of the supply chain related decisions and actions are often motivated by a selfish pursuit to maximize the firm's own benefits, valuable insights regarding the antecedents on information sharing are likely to be derived from game theory (Straub et al., 2004). Further, as game theory has seldom been used as a theoretical perspective to explain the antecedents on information sharing (Ellram & Cooper, 2014; Ketchen & Hult, 2007), our research is guided by the following question: *Can a game-theory based matrix help to identify and to organize the antecedents on information sharing within buyer-supplier relationships?*

Especially a game-theoretic setting allows firms and researchers to explain the importance of information sharing and its antecedents on information sharing; as the discrepancy between realizing the highest supply chain performance (by mutual information sharing) and having the highest risk to suffer from opportunistic behavior (in case of unilateral information sharing) can be demonstrated. Game theory allows the analysis and conceptualization of various antecedents on information sharing, influencing both magnitude and symmetry of information sharing. More specifically, the effect of differences in bargaining power on information sharing and direct-indirect supply chain members can be assessed using game theory (Straub et al., 2004). Despite this, existing research on game theory in the area of supply chain management has focused towards quantitative analysis of calculating the buyer-supplier pay-offs (e.g., Gerard P. Cachon & Netessine, 2004; Nair et al., 2011; Simchi-Levi, Wu, & Shen, 2004). We believe that using a more qualitative approach towards analyzing supply chain behavior by adapting basic game theoretical concepts is feasible for understanding the antecedents on information sharing (Heide & Miner, 1992; Parkhe, 1993a, 1993b). Therefore, we develop a game-theory based matrix enabling researchers and practitioners to organize antecedents on information sharing and identify inter-relations between the antecedents using the simplified form of game theory, the prisoners' dilemma game.

2 Theoretical Development

Collaboration among supply chain members positively affects information sharing, therefore allowing firms to increase their performance (Mithas, Ramasubbu, & Sambamurthy, 2011; Straub et al., 2004). Firms can realize the highest profits through jointly generated exchange relationships (Dyer & Singh, 1998). However, firms may have strategic considerations that prevent them from sharing information (Fawcett et al., 2007; H. L. Lee et al., 1997). Information sharing is complicated by factors such as the alignment of incentives (Fawcett, Waller, & Fawcett, 2010; Karen, 2010), trust and beliefs (Barratt, 2004; Petersen, Ragatz, & Monczka, 2005), and data quality concerns (Forrester, 1961; Strong, Lee, & Wang, 1997). In this section, we provide some overview on information sharing in the context of supply chain management, antecedents on information sharing, and discuss previous findings on the application of game theory in the context of supply chain management.

2.1 The role of information sharing in supply chain management

Supply chain management is facilitated by inter-organizational information sharing (Fawcett, Wallin, Allred, Fawcett, & Magnan, 2011; Langley & Holcomb, 1992). The information shared within the supply chain can range from transactional, to operational and strategic (Seidmann & Sundararajan, 1997). While transactional information sharing is a necessary condition to streamline the exchange of goods, the sharing of operational information allows firms to establish more efficient supply chain procedures and actions (Angulo, Nachtmann, & Waller, 2004). Finally, strategic information sharing can generate additional rents and focuses on the sharing of proprietary information or financial information (Gérard P. Cachon & Swinney, 2011; Gavirneni, Kapuscinski, & Tayur, 1999). Previous research has shown that operational and strategic information sharing allows the improvement of supply chain performance (H. L. Lee, Padmanabhan, & Whang, 2004; Straub et al., 2004).

Despite the recognized benefits of information sharing for supply chain coordination (Klein & Rai, 2009; H. L. Lee et al., 2004), organizations may choose not to share information when it is perceived that information asymmetries can be used as a source of competitive advantage and rent generation, especially when relationships are more opportunistic and/or purely transactional (Kampstra et al., 2006; Nair et al., 2011).

2.2 Antecedents on information sharing in supply chain management

Previous research has shown that information sharing is influenced by various factors such as the level of trust (Gérard P. Cachon & Lariviere, 2001a, 2001b; Klein & Rai, 2009), cultural aspects (Dyer & Nobeoka, 2000; H. L. Lee & Whang, 2000), or bargaining power (Fawcett, Fawcett, Watson, & Magnan, 2012)

Information management capabilities of firms refer to the accuracy of data and the timeliness of information, and therefore contribute towards the quality and effectiveness of information sharing (Malhotra, Gosain, & El Sawy, 2007; Simatupang & Sridharan, 2005). Supply chain knowledge allows employees to identify and share relevant information, and enables them to use information effectively to steer the supply chain (Bailey & Francis, 2008; Fawcett et al., 2008a). Trust on the other hand represents the adhesive, flexible, and informal tie between socio-political and political behaviors (Shub & Stonebraker, 2009; Whipple & Frankel, 2000). Trust can therefore be viewed as a mechanism that enables firms to overcome the social dilemma between cooperation and competition (Clark & Lee, 2000). Isolated specific behavior often results in a tit-for-tat strategy causing lower rents (Axelrod, 1984). Therefore, firms have to consider their bargaining power position to gain mutually economic value from cooperation (Agarwal, Croson, & Mahoney, 2010). Further, socio-political behavior determines economic decisions, such as decisions regarding supply-chain specific investments to strengthen collaboration, and cultural factors such as inter-firm learning processes (Doz, 1996; Dyer & Nobeoka, 2000; Nair et al., 2011), knowledge about supply chain management, and the (technical) ability to apply it within the supply chain (Hult, Ketchen Jr, & Slater, 2004; Richard & Devinney, 2005).

In supply chain management, the bullwhip-effect illustrates an exemplary supply chain problem of firms coping with cooperation and competition as a result of inter-dependency between antecedents such as incentive structures, trust or timeliness of information (H. L. Lee et al., 2004). A dilemma faced by the supply chain partners is whether to maximize their own interest or the interests of the supply chain as a whole. A short-term individual partner's self-interested choice, albeit rational, will lead to a failure of a collaborative supply chain; which therefore pose a social dilemma for each of the partners (Dawes, 1980; Fawcett, Magnan, & McCarter, 2008b; Yamagishi, 1986). This may result in rational but uncooperative behavior, shortage gaming (Gérard P. Cachon & Lariviere, 1999; H. L. Lee et al., 1997) and threats for firms such as high inventories, stock-out situations or markdown of products (Straub et al., 2004). The presented dilemma stresses the need and importance to identify the inter-dependencies of antecedents on information sharing to improve supply chain performance (Fawcett et al., 2008b; Johnson, Elliott, & Drake, 2013). However, dynamic elements in supply chain collaborations increase the complexity to organize the antecedents on information sharing (Fawcett et al., 2012).

2.3 Application of game theory in supply chain management

Game theory has been used previously in the management and strategy literature in order to explain various aspects of inter-firm actions and behaviors. For instance, the prisoners´ dilemma game was used as a framework to explain cooperation within strategic alliances settings (Parkhe, 1993a, 1993b). It can also be used as a theoretical perspective to examine inter-organizational learning and knowledge sharing (Liu, Ray, & Whinston, 2010). Further, it has been suggested that using a game-theoretic framework for examining inter-organizational relationships will allow researchers to analyze future interactions, communication, and performance of supply networks and come up with useful insights regarding them (Heide & Miner, 1992; Straub et al., 2004).

Previous research has shown that from a bargaining perspective, the power of a firm in a supply network depends firstly on the product itself, and secondly on the holistic bargaining power of the firm within the industry (Choi & Sethi, 2010; Porter & Millar, 1985). Although the general willingness of firms to engage in supply chain management initiatives can be realistically assumed, firms may focus on increasing (unilaterally) their profits (Argyres & Liebeskind, 1999; Nair et al., 2011). Therefore, from a supply chain perspective it is necessary to analyze how bargaining power, inter-relational dependencies, and other factors influence information sharing and value creation (Barratt, 2004; Ketchen & Hult, 2007).

Game theory has previously been used to analyze supply chains, supply networks and its players (Gerard P. Cachon & Netessine, 2004). For instance, Nair et al. (2011) study the influence of investments on bargaining power and inter-firm relationships. Phelan et al. (2005) examine behavior in alliances with exit options, whereas Berstein and Federgruen (2005) focus on equilibrium behavior of decentralized supply chains with competing retailers. Given the applicability of game theory in knowledge sharing and inter-organizational learning, in explaining alliance performance and different aspects of supply chain behavior, we believe that a game theory based matrix is applicable for identifying and organizing antecedents on information sharing as well as their inter-relations.

3 Information sharing matrix

We use game theory, in particular the prisoners' dilemma game to depict different antecedents on information sharing among supply chain members. We use previously published cases to make the antecedents on information sharing apparent and to develop our propositions. Prisoners' dilemma is an example of a game, which explains why two individuals might not cooperate even if it is in their best interest to do so. In this game, players can have four different strategies that are mutual cooperation (MC), unilateral cooperation (UC), unilateral defect (UD) and mutual defect (MD). The preference of each player is UD > MC > MD > UC. However, the highest payoff can be obtained through mutual cooperation. We limit our scope of analysis towards antecedents on operational and strategic information sharing, as they enable supply chain members to compete in the industry and support mutual value creation (Dyer & Singh, 1998; Leng & Parlar, 2009; Thietart, 2001); while transactional information exchange is a necessity for executing basic supply chain processes in business relationships (Klein & Rai, 2009; Seidmann & Sundararajan, 1997).

We differentiate between mutual information sharing (equivalent to MC), unilateral information sharing (equivalent to UD and UC) and no information sharing (equivalent to MD) as three different information sharing behaviors. When members of the supply chain mutually share operational and strategic information, it is referred to as mutual information sharing (MISH) relationship. If information is shared by only one of the member firm with either its upstream or downstream partner, the relationship can be regarded as unilateral information sharing (UISH) relationship. In contrast, no information sharing (NISH) relationships limit information sharing to only transactional information, while very little operational and strategic information is shared. Mutual information sharing can be considered the most preferable choice from the perspective of the overall supply chain since it can help both upstream and downstream supply chain members to improve their business processes. To realize a local optimum, unilateral information sharing is the most preferable choice from the perspective of a firm in the supply chain. No information sharing can result in the lowest firm and supply chain performance. Further, irrespective of firms´ bargaining power, they may choose to share information due to more uniform distribution of performance gains resulting from such information sharing.

Based on the above discussion, we develop the information sharing matrix (Table 1). The matrix is structured according to the information sharing strategies of the buyer and the supplier. The x-axis represents the buyer's information sharing strategies – no information sharing (NISH), and information sharing (ISH). Similarly, the y-axis represents the information sharing strategies of the supplier. The different forms of information sharing represent the discussed information sharing behaviors from previous sections. Therefore, when the buyer follows a strategy of no information sharing, while the supplier has to share information, the supply chain can be characterized as having unilateral information sharing (UISH). Similarly, when both buyer and supplier follow a strategy of sharing information with each other, then the supply chain is characterized as having mutual information sharing (MISH). In case both firms follow a no information strategy, the supply chain can be regarded as having no information sharing (NISH).

		Buyer	
		No Information Sharing	**Information Sharing**
Supplier	**Information sharing**	UISH	MISH
	No information sharing	NISH	UISH

Table 1 – Information sharing matrix

3.1 No information sharing

This relationship is characterized by firms involved in a purely transactional relationship. Equal bargaining power and missing alignment of antecedents among parties is reflected in their information sharing behavior (Kumar, 1996). Only transactional information, necessary for the successful completion of the transaction, is shared. The information sharing behavior in this relationship can further be characterized as fearful. Firms fear losing power and revenues and therefore limit information sharing to a transactional level. The availability of other alternative players allows each player to change their transactional partner without any significant transaction cost. Therefore, there is very little motivation among players to align their antecedents and to share information in a transactional relationship. As this results in no information sharing (Kang, Mahoney, & Tan, 2009; Klein & Rai, 2009; Richard & Devinney, 2005), we propose:

P1:Sole usage of bargaining power results in no information sharing.

3.2 Unilateral information sharing

The motivation to share information mutually or unilaterally depends firstly on commonly aligned antecedents, and secondly on internal strategic considerations of partners (Seidmann & Sundararajan, 1997). In unilateral information sharing relationships, the stronger partner (buyer or supplier), specifies the settings, rules and norms for sharing information, and the monetary share within the supply chain; the weaker partner complies with these specifications. More specifically, it depends on the stronger supply chain partner to use (request) the information egoistically or co-operatively. While contracts are a common way to create a safe relational basis (whether formal or informal) for two or more firms (Poppo & Zenger, 2002), firms can enforce a reward or penalty system within contracts to strengthen their bargaining power position, and ensure desired behavior such as information sharing (Maloni & Benton, 2000). In consequence, different information sharing behaviors are observed depending on the alignment and of antecedents and their inter-relations.

The Dell case (Magretta, 1998) indicates the strong bargaining power of Dell (strong buyer), that allows them to specify, manage and control information sharing in the upstream supply chain. While operational information is shared mutually, strategic information is unilaterally shared by Dell with its upstream channel partners. There are no explicit attempts towards aligning the antecedents within the supply chain. However, Dell expects its suppliers to use the shared information to optimize their own supply chain processes in order to realize the monetary expectations and its sharing ratio from the perspective of Dell. The example indicates the influence of bargaining power towards information sharing and value creation in supply chains, its mediating effect on information sharing, and its impact on the monetary share among supply chain partners. Therefore, we propose:

P2:Contracts prevent opportunistic behavior.

P2a:If contracts are used to strengthen a firm´s bargaining power position,
information is shared unilateral.

3.3 Mutual information sharing

Mutual information sharing includes operational information, i.e., point-of-sales data (H. L. Lee & Whang, 2000), and strategic information, i.e., margin structures, marketing strategies (Klein & Rai, 2009). In supply chain relationships, the different level of shared information is determined by various antecedents such as the dependency of firms within the firms´ power-relational supply chain liaison. While mutual alignment of antecedents allows collaborating firms to increase the level of shared information, lack of alignment leads to lower levels of information sharing resulting in diminished supply chain performance (Gérard P. Cachon & Lariviere, 1999; Li & Zhang, 2008). Equal bargaining power allows firms to focus on the alignment of antecedents (Shapiro, 1977) and avoid gaming (Liker & Wu, 2000; Simatupang

& Sridharan, 2002). Therefore, bargaining power can initiate information sharing or defect information sharing. For example, in case of gaming, contracts can align incentives and safeguard collaboration as contracts lower the risk of suffering from opportunistic behavior fostering supply chain specific investments (Gérard P. Cachon & Lariviere, 2005; Klein & Rai, 2009; Williamson, 1989). Further, contracts can positively complement relational factors such as trust enabling mutual information sharing (Rai, Keil, Hornyak, & Wüllenweber, 2012).

For example, Toyota as a strong buyer manages its supply chains activities with a co-operative approach by cultivating, institutionalizing and requesting mutual information sharing among supply chain partners in the Toyota network (Dyer & Nobeoka, 2000). Toyota eliminates the notion of proprietary knowledge, allows inter-organizational learning; and engages suppliers in synergistic investments. This behavior can be seen as an investment towards the relationship since the intention is to increase collaboratively the performance of the network as a whole, while losing bargaining power is less important. In consequence, the antecedents of all supply chain members are aligned (Lieberman & Asaba, 1997; Nair et al., 2011). We propose.

P2b:Contracts enable mutual information sharing by acting as pre-requisite to build a trustworthy relationship, if firms are willing to collaborate.

P3:Bargaining power can be used to initiate information sharing.

Furthermore, the case of three equally strong firms partnering in the UK sheep meat industry (Bailey & Francis, 2008) reveals information asymmetries resulting in medium performance although a collaborative planning, forecasting and replenishment tool was used for information sharing (Fliedner, 2003). In this example, all players created a trustworthy relationship in which they shared information mutually, providing the chance to co-operate closely and to solve the performance issues within their supply chain. However, this did not happen, primarily due to the lack of information management capabilities and supply chain knowledge. In contrast, Procter & Gamble and Wal-Mart formed a relationship over time and aligned all antecedents on information sharing resulting in mutual information sharing. This allowed both firms to implement sophisticated solutions such as vendor-managed inventory and make use of shared information to realize higher supply chain performance. (Kumar, 1996). Based on the examples, we propose:

P4:Trust is a necessary condition to realize mutual information sharing.

P5:Trust leverages information management capabilities and supply chain knowledge

P6:Supply chain knowledge and information management capabilities are sufficient conditions to realize the highest level of information sharing.

In addition, firms can realize the highest performance for the supply chain or network as a whole by mutually sharing information and aligning their antecedents (Kumar, 1996), lack of alignment lowers the performance despite mutual information sharing (Bailey & Francis, 2008). We propose:

P7:Supply chain knowledge allows firms and their supply chain partners to realize the highest supply chain performance.

To summarize: Global supply chain collaboration might lower the actual benefits of individual firms within the supply chain compared to the overall supply chain performance (Ba, Stallaert, & Whinston, 2001), reflecting the need and challenge to collaboratively align the antecedents (Fawcett et al., 2012; Fawcett et al., 2008a; Fawcett, Ogden, Magnan, & Cooper, 2006). Therefore, alignment of antecedents can be seen as mandatory task to reward supply chain members for information sharing by distributing risks and costs to ensure a fair distribution of benefits across the network (Narayanan & Raman, 2004). However, the antecedents, especially monetary incentives, are not always aligned (Clark & Lee, 2000). The dilemma faced by firms is whether to use the information egoistically or co-operatively (Fawcett et al., 2008b).

Table 2 represents the propositions within our matrix. While the embraced propositions represent a given condition, propositions in arrows visualize an effect. For example, trust as necessary condition does not state an effect, while trust leveraging information management capabilities and supply chain knowledge proposes an effect. In addition to proposition four, we introduced a gray area, which reflects that even though firms trust each other, it occurs that information is shared only unilateral.

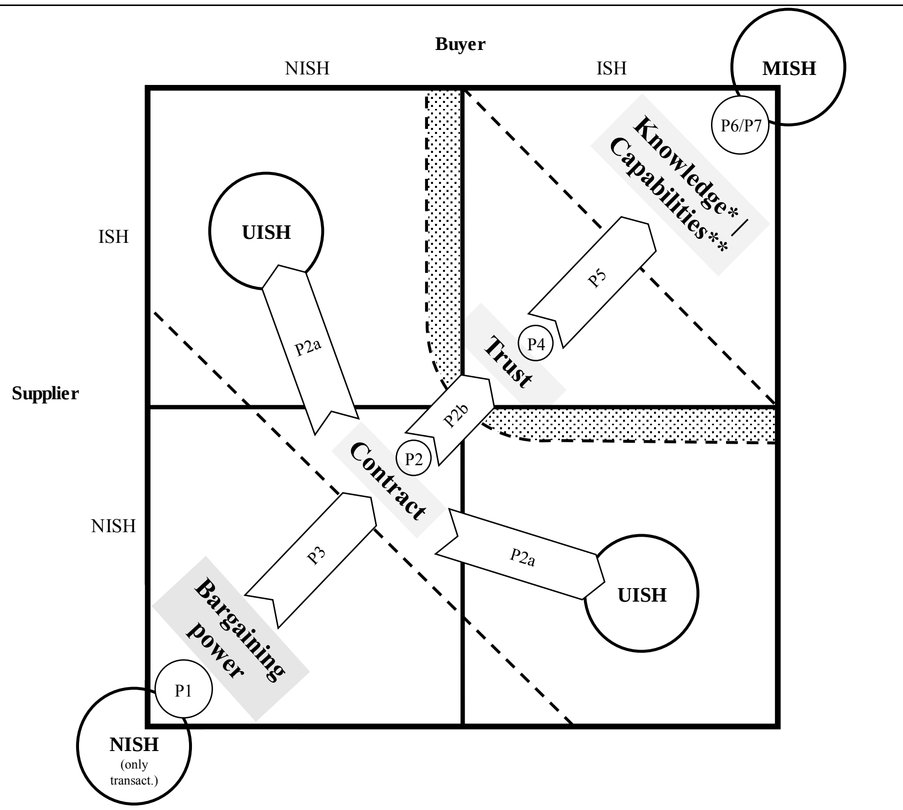

Table 2 – Antecedents and their influence on information sharing

Note: MISH: mutual information sharing; UISH: unilateral information sharing; NISH: no information sharing; ISH: information sharing; SLA: Service-level agreement; *Knowledge represents supply chain knowledge; ** Capabilities represent information management capabilities

4 Research method

4.1 Sample and Context

The matrix developed in the previous section provide the possibility of analyzing information sharing behavior from a game theoretic perspective, and helps to extend and to refine inter-relations between antecedents on information sharing. Moreover, our objective is to provide a possibility for firms to derive information sharing strategies based on our matrix.

In order to elaborate the matrix, we searched for polar supply chain types. Polar types facilitate theory building and testing because the differences in the phenomenon under consideration (in our case: antecedents on information sharing) tend to be more evident than in similar contexts (Eisenhardt, 1989; Pettigrew, 1990). As a first step, we conducted expert interviews to find support for the general idea of the matrix, being able to identify and organize antecedents on information sharing and therefore its relevance for supply chain management.

We chose the experts from different industries based on their experience, responsibilities within their firms and knowledge in the field of supply chain management from our personal networks. Further, we ensured that the different forms of information sharing were represented by our experts (and their supply chains). Besides validating the relevance of the framework, the experts allowed us to address supply chain related problems (Offermann, Levina, Schönherr, & Bub, 2009). Moreover, the expert interviews provide a unique perspective that encompasses organizational, technological, as well as conceptual challenges. The interviews allowed us to identify antecedents for differences in information sharing behavior as perceived by our supply chain experts (Bandara, Indulska, Chong, & Sadiq, 2007).

In a second step, we used case study research to gain further insights into the antecedents on information sharing among supply chain partners. Case study research allows for observing unexplored dynamics such as the inter-relations and inter-dependencies of determinants on information sharing (Eisenhardt, 1989; Locke, 2001; Yin, 2009). This process ensures that our analysis represents a valid sample, allows replication of findings, and the extension of theory by confirming our matrix based on our data (Eisenhardt, 1989).

4.2 Data

We initially interviewed supply chain management experts (n = 8) over a four-month period (September 2011 to December 2011). Each interview lasted between 45 minutes to 1 hour. Table 3 gives an overview. All interviews were face-to-face meeting and the interview questions were pre-checked with two independent researchers not involved in this research to ensure a high level of construct validity (Yin, 2009). The expert interviews had a semi-structured interview approach, anticipating the possibility for the interviewees to link their experiences and perceptions in order to think, reflect and report about topics, themes and processes influencing information sharing behavior in supply chains (Kramp, 2004; Myers & Newman, 2007).

Expert	Industry	Position
Alpha	Automotive industry	Plant manager sequencing center
Beta	Automotive industry	Manager Lean Manufacturing EMEA (formerly: Di-

		rector Supply Chain Management Korea)
Gamma	Furniture industry	Manager Supply Chain Management
Delta	Furniture industry	Manager Supply Chain Management – Logistics
Epsilon	Telecom. infrastructure industry	Program Manager Global Trade Management
Zeta	Telecom. infrastructure industry	Senior Supply Chain Purchaser
Eta	Life Science Technology	Head of Supply Chain Planning & Operations Research
Theta	Semi-conductor industry	Head of Supply Chain Innovations

Table 3 – Expert interviews

To explain the inter-relations and inter-dependencies between the antecedents on information sharing, we conducted one embedded-single case study (3 supply chains), one multiple case study (4 supply chains), and one single case study (7 supply chains). The analyzed supply chains were chosen based on comparability aspects and technological influences referring to information sharing from our personal network. We identified one firm from the tobacco industry, four firms from the retail industry and one firm from the aircraft industry; this allowed us to analyze and interview upstream and downstream supply chain partners. Having three different industries among the cases is not necessarily a limitation, as bargaining power and incentive alignment are important factors across different industries. In fact, quantitative studies on supply chain information sharing also do not limit their sample to one specific industry (e.g., Klein & Rai, 2009; Straub et al., 2004).

We interviewed employees from the Sales-, Purchase-, IT- and Logistics-department and general management. For example, we interviewed retail shop owners, analyzed the information on the vending machines, observed employees and reviewed internal documents at the wholesaler, and questioned employees (operational and managerial level) at the tobacco manufacturer. In sum, we interviewed 41 employees from 19 different firms from December 2012 to April 2014, each interview lasting between 45 minutes and 1.5 hours on average. As in the expert interviews, we chose the interviewees based on their knowledge and responsibility for their firm´s supply chain management. Most interviews were conducted personally at the respective sites, while four interviews were conducted via phone. Most interviews were audio taped and transcribed. In cases where this was not allowed, we took notes manually. Additionally we reviewed internal documents about processes, especially about the information flows and material flows. In order to clarify statements, which were either unclear or in conflict with the documents, we conducted follow-up conversations with nine interviewees from four firms via E-Mail and phone.

The chosen case studies can be considered polar from two different perspectives: First, the used technology differs among and within the cases from manual towards electronic information sharing. Second, the sizes of supply chain partners differ. More specifically, in the tobacco industry the size of supply chain partners decreases as one moves downstream towards the consumer, while in the retail industry it is the opposite. Further, in the aircraft industry, we have big firms at the beginning and the end of the supply chains. Polar case studies allow us to identify the relation between different antecedents such as bargaining power or supply chain knowledge and information sharing.

4.3 Data analysis

In an iterative fashion, we developed our data structure balancing between theory and data. Therefore, we traveled back and forth between data from expert interviews and case studies resulting in an emerging structure to validate our matrix and propositions (Locke, 2001; Michael G. Pratt, 2009; Strauss & Corbin, 1998)

4.3.1 Step 1. Developing the data structure

Based on the reviewed literature, we developed theoretical dimensions using a top down process (Locke, 2001). In a first step, these theoretical dimensions were used to develop a structure and questions for the expert interviews. Secondly, we validated and enriched the theoretical dimensions, formed provisional categories and some initial first-order codes by applying a bottom up open coding process using the data from our expert interviews (Locke, 2001; Michael G Pratt, Rockmann, & Kaufmann, 2006; Strauss & Corbin, 1998).

Common statements were used to consolidate categories and align our theoretical dimensions marking a move from open to axial coding (Locke, 2001; Strauss & Corbin, 1998). Based on this process, we were able to create a data structure with theoretical dimensions, theoretical categories, and first-order codes. During the process, we further enriched our structure with a fourth column labeled as theoretical sub-categories reflecting literature which has become evident during the analysis of the interviews. An excerpt of the coding structure can be found in Table 4. By using induction and deduction, we identified relations between theoretical categories, and between theoretical categories and theoretical dimensions. For example, complaints about an out of stock situation were associated with supply chain knowledge and supply chain training in firms. We kept these relations in mind, as we revisited the data to see whether and how the data fitted or not (Locke, 2001; Michael G Pratt, 2008).

First-Order Codes	Theoretical Sub-Categories	Theoretical Categories	Theoretical Dimension
Statements about partners´ expertise in the field of supply chain management	Complement to trust vs. Substitute for trust (Ireland and Webb 2007) Influence on relationships (positive / negative) (Maloni and Benton 2000)	**Non-Economic Power:** Acceptance of punishment (subjective feeling or judiciary) (French and Raven 2001; Maloni and Benton 2000) Usage of expertise (French and Raven 2001; Maloni and Benton 2000) Desire to connect (French and Raven 2001; Maloni and Benton 2000; Webster 1995)	**Bargaining Power** (Etgar 1978; French and Raven 2001; Hersey and Blanchard 1969; Parkhe 1993b; Williamson 1989)
Statements about reluctance of customers to change brand Statements about being among “the few companies in Germany who have distribution with all four suppliers of vending machine products”			
Statements about value of products, market position of brand, visibility towards customers, impact on sales			
Statements about rewards such as “the smaller the market share, the more customer-friendly the nego-		**Economic Power:** Stimulate/Force behavior (economical in-/dependence) (Daft	

tiations are” Statements about clustering of customers according to ABC-analysis		2009) Punishment vs. Reward-System (Etgar 1978; Maloni and Benton 2000; Molm 1997)	
Negative comprehension of bargaining power and “being forced” to achieve sales targets Statements about negative use of power such as “would not help any party” Statements about losing the bargaining power position due to information sharing such as “fear their own position among competitors if information would be earlier available” Strong bargaining power position due to a high competition in the supply chain	Stimulate cooperation (dependent on culture and integration) (Cox 1999; Fawcett et al. 2006; Klein and Rai 2009; Webster 1995; Yeung et al. 2009) Harmful usage of coercive power (Maloni and Benton 2000; Molm 1997; Skinner et al. 1992) Coercive power vs. goodwill and/or trust (relational norms) (Ireland and Webb 2007) Higher level of trust will decrease the perception of harmful coercive power (Yeung et al. 2009) Significance of coercive power for supply chain integration (Webster 1995; Yeung et al. 2009)		

Table 4 – Excerpt of the Coding Scheme

4.3.2 Step 2: Revisiting the inter-relations using case study research

Based on the results from our expert interviews, we developed further questions (semi-structured interview guideline) starting from the interview statements, identified (theoretical) dimensions, and by using further literature. This process ensured a direct link between the used code words and the questions, resulting in a catalogue of 145 questions; ordered according to the theoretical dimensions. We then, consulted the same independent researchers and five supply chain management consultants to pre-check the questions to ensure construct validity of our case studies findings (Yin, 2009).

In an iterative fashion, we analyzed a variety of documents, made observations and conducted interviews to gain a better understanding of antecedents on information sharing in supply chains (A. S. Lee & Baskerville, 2003; Yin, 2009). As an addition, we also compared the statements of our experts with the results from our case studies to revisit already identified inter-dependencies between antecedents. Especially the results from our case study allowed us to (1) gain insights on the importance of antecedents and its impact on information sharing, (2) identify inter-dependencies between antecedents in specific situations, and (3) to collect much data for the evaluation of our matrix and propositions.

The described process allowed us to reach saturation, i.e., no additional critical enrichment of our data could be achieved beyond a point, therefore giving us the confidence in our results (Eisenhardt, 1989; Thietart, 2001; Yin, 2009). The expert interviews and the interviews during the case study were independently coded and analyzed by three researchers following the data analysis process (see section below). Rival explanations were resolved within group discussions among the authors (Krippendorff, 2012; A. S. Lee & Baskerville, 2003; Yin, 2009). By following this process we ensured compliance with the quality criteria for case studies suggested by Yin (2009). Hence, validity and reliability is expected to be high.

4.3.3 Step 3: Delimiting theory by aggregating findings

In a final step, we aggregated our findings to derive insights about inter-relations and inter-dependencies of antecedents on information sharing. This allowed us to explain how different antecedents need to be aligned in order to affect information sharing. Further, these findings validate our matrix and indicate inter-relations and inter-dependencies between categories and dimensions. For example, our findings indicate that contracts are less important for information sharing in supply chain if firms mutually trust each other. Once we identified the inter-relations and inter-dependencies, we delimited the fit/misfit in our matrix. Table 3 shows the process that we followed, listing the theoretical dimensions, the theoretical categories, the theoretical sub-categories and our first-order codes. Accordingly, by going forth and back, we ensure a broad theoretical scope, extant coverage of literature and the analysis of real-world data. This enhances us to discuss how our matrix can be used to analyze antecedents on information sharing, and provide practitioners with a possibility to manage and govern information sharing more efficiently (Eisenhardt, 1989; Locke, 2001; Yin, 2009).

5 Results of the Expert interviews

Our experts report either the limitation of transactional information sharing or unilateral information sharing in case of a stronger bargaining power position of the partner. However, in case of trustworthy relationships, operational or even strategic information is orally shared. However, some industries still have to acquire basic supply chain knowledge and initiate programs to share information. Supply chain knowledge is also mentioned by our expert from the telecommunications infrastructure industry as *"[…] key for today´s success in a globalized world" (Expert Epsilon)*, as they suffered due to wrong information of customs information *"[…] resulting in financial damages, high inventories and unsatisfied customers" (Expert Epsilon).*

While long-term relationships enable employees to interpret the message from the customer and transfer the message into appropriate reactions, opportunistic behavior can prevent information sharing. This problem seems to be especially relevant in cases where the partner has a better bargaining power position *"This is especially true for our relationships with our downstream partners; we build up supply chain knowledge and invest money, while they want to have all of the gains" (Expert Theta).*

Moreover, it was said, that unilateral information sharing allows customers to control the activities of suppliers. Additionally, business is sometimes perceived as game and not as collaborative approach, especially if different departments such as purchasing, logistics, quality, or production are involved. Internal political games and different department goals influence the supply chain strategy and information sharing behavior, as supply chain departments focus on the daily supply of products, while purchasing departments focus on opportunistic behavior of suppliers.

We used the expert interviews to identify important antecedents on information sharing, as previous literature suggest many antecedents. We further these findings to revisit the literature and add related antecedents to the found antecedents such as contracts are in a close relation to trust. Table 5 presents the found antecedents, including exemplary statements, and the effect on information sharing; marking a starting point for choosing the case studies, and for the development of the case study interview guidelines.

Antecedent	Statement	Effect on ISH
Bargaining power	*"Information is shared due to the better bargaining power position of the customer" (Expert Alpha), "Information is shared only in one direction" (Expert Beta)*	Unilateral information sharing
Opportunistic behavior	*"We would like to receive further information from our suppliers to improve our supply chain, while the distribution of efficiency gains often prevents mutual information sharing" (Expert Theta)*	No information sharing in case of egoistic behavior
Bargaining power	*"This allows the customers to control us and cover their problems" (Expert Beta)*	Unilateral information sharing
Political games (within the firm and among supply chain partners)	*"you try to develop the relationship towards operational and strategic information sharing" (Expert Epsilon) vs. "we try to use our bargaining power position to set prices, rules and norms. Further, in that case [single source supplier], we try to develop the supply chain relationship with the supplier and simultaneously find alternatives to avoid dependencies and create opportunities in case of opportunistic behavior from the supplier." (Expert Zeta)*	Limited information sharing. Higher level of information sharing in case of single sources.
Trust	*"Trustworthy relationships allow us to receive un-official information" (Expert Alpha)*	Enables strategic information sharing
Supply chain knowledge	*"[…] not due to a missing willingness, this is due to missing supply chain knowledge. We are still ten twenty years behind the automotive industry" (Expert Gamma)*	Information sharing is limited
Long-term orientation	*"We learned over time [… how] to balance our production and logistic capacities" (Expert Alpha)*	Towards mutual information sharing

Table 5 – Results: Expert Interviews

6 Results of the case studies

The *first* case study was chosen to explain information sharing patterns in retail fashion supply chains by using a multiple-case study approach. We analyzed four supply chains, each consisting out of two nodes: supplier and buyer (here: Original Equipment Manufacturer (OEM)). The four OEMs offer high quality fashion products within the medium and premium price segment. The *second* case study analyzed information sharing behavior in an IT hardware supply chain within the aircraft industry using a single-embedded approach. We analyzed four supply chains, involving between two to four suppliers plus the customer. The supply chains ensure the supply of mobile phones, portable/stationary computers, printers, and projectors. From the customer´s side, we interviewed the buyer from the IT department and a general buyer from the purchasing department, while at the suppliers´ side we interviewed sales and logistic functions. The *third* case study analyzed the tobacco supply chain using a single-embedded case study approach. The analyzed supply chains had three nodes; one node upstream and one node downstream, having a family-owned wholesaler in the middle (being the major wholesaler in his state). In the upstream supply chain, we interviewed logistics and purchasing functions at three cigarette manufacturers, each big-, medium- and small-sized with regard to their market-share. At the wholesaler, we interviewed sales, purchasing, logistics and IT functions plus the management board. In the downstream supply chain, we interviewed two retailers and two groups of cigarette vending machines. The retailers and vending machines can be differentiated by either its electronic linkage to the wholesaler or manual processing. For example, the vending machine can report problems via Wide-Area-network; the electronic cash system automatically takes stock levels and processes electronic documents such as delivery notes, while the other retailer uses a manual cash machine without any electronic features.

6.1 Information management capabilities and information sharing

We found that the technical capabilities vary between the industries and firms. While there are good technical capabilities within the tobacco industry, information is shared using multiple technologies such as phone, fax, or EDI. This is mainly due to missing alignments from a strategic perspective. Although all firms support electronic data transfer, we found that firms failed to align and adjust their information sharing processes towards actual possibilities. Within the retail industry and aircraft industry, most information systems are not linked and information has to be transferred via phone, fax, and E-Mail resulting in a high error rate, data inconsistencies, and longer lead times.

Despite the technical problems, firms and their employees lack supply chain knowledge, as they do not consider operational and/or strategic information sharing as a possibility to improve supply chain performance. However, we also found positive examples for mutual information sharing resulting in supply chain collaboration. Within the tobacco industry missing information management capabilities, especially supply chain knowledge prevented firms from realizing higher supply chain performance. More specifically, the tobacco wholesaler was neither able to provide its employees a sufficient information system and training nor were processes questioned from the employees. Our findings from the aircraft industry show a similar picture, as the customers share only transactional information and uses his bargaining power position to reduce prices. However, in this case, this might be due to missing trust or the usage of bargaining power. Following up on the tobacco case study showed us the importance of supply chain knowledge to use information for supply chain performance improvements.

Antecedent	Statement	Remark	Proposition
Information management capabilities	*We currently have no supply chain management software. […] (Retail Case Study, Firm Alpha); We work with Excel […]. Information Shar-*	These statements reflect the importance and the influence of information management capabilities on transaction costs,	Partly supports P6

	ing is done via E-Mail, phone and Fax." (Retail Case Study, Firm Alpha)	data quality, and connectivity among members in the supply chain.	
Supply chain know-ledge	*"I don't know why I am doing this. This is how it has been shown to me (Tobacco Case Study, Wholesaler, Scheduler)"; "We reduced our inventory value level by one mil-lion" (Tobacco Case Study, Whole-saler, CEO)". "I have no idea how we could use information to im-prove the supply chain" (Aircraft Case Study, Integrated Service Pro-vider)*	Even though there is mutual information sharing in trust-worthy relationships, supply chain knowledge and infor-mation management capabili-ties are of importance to realize the best supply chain perfor-mance. After acquiring supply chain knowledge, the wholesal-er could improve the inventory by one million after four months.	Supports P6 / supports P7
Supply chain know-ledge	*" [...] we will share any infor-mation which is needed to supply the goods on time, but we do not see any additional value to share Point-of-Sales data." (Retail Case Study, Alpha)*	Although partners are willing to share information, there is no awareness on how operational information sharing improves supply chain performance.	Supports P6

Table 6 – Excerpt of the Case Study Coding: Information Management Capabilities

6.2 Contracts, trust, and information sharing

We found that trust is more important than contracts within the tobacco industry. This is influenced by inter-dependencies (although there are differences in bargaining power) between firms, historically grown structures resulting in clear definition of responsibilities linked with possibilities to improve performance and price-transparency for cigarettes. As mentioned by one the retailers, a contract equals coercion and he would terminate the relationship. Furthermore, combining a contract with information sharing concepts is not seen as a good practice, as *"reality changes faster than contracts" (Tobacco Case Study, Supplier C)*. Moreover, the wholesaler reported that formal contracting was not done in the past and agreements were only informal. Nowadays, contracts are used to avoid misunderstandings. Further, contracts are used for certain kinds of strategic information sharing such as promotional poster in vending machines, sales data from promotions and the definition of marketing actions with yearly volumes. They can therefore lead to an overall improvement of the mutual level of trust between the supply chain partners and improve information sharing.

These findings are completely different from the findings within the aircraft industry. The supply chain is only driven by bargaining power. Firms do not trust each other, and even internally – among department – political games are played. Therefore, contracts are generally identified as a prerequisite for collaboration, resulting in general contracts combined with service level agreements (SLA) and reward/punishment systems. Although suppliers are not punished during the year, the penalties are taken into yearly negotiations to improve the bargaining power position of firms. Positive examples from the retail industry show that long-term relationships foster trust and thereby strategic information sharing such as access to inventory data and point-of-sales data, whereas in case of the absence of trust, no operational or strategic information is shared and contracts are used to ensure the firms´ own performance, indicating selfish behavior from a supply chain perspective.

Antecedent	Statement	Remark	Proposition
Contract and Bargaining power	*“I work with whom I want […] a contract would be a coercion […]” (Tobacco Case Study, Retailer A)*	In this specific case, contracts are perceived as opportunistic behavior.	Rejects P2b
Trust	*“I share information if I sense the relationship as being a trustworthy one […] then there is also an absolute price-transparency”; “[…] a win-win situation has to be given, independent from information sharing” (Tobacco Case Study, Retailer A)*	Trust enables mutual information sharing.	Supports P4
Contract	*“[…] reality changes faster than contracts […] therefore […] contracts can be used to align general issues in business relationships […] information sharing is handled later on.” (Tobacco Case Study, Supplier C)*	Contract includes only basic information such as a general interest in information sharing.	Supports P2b
Contract	*“Can you imagine a relationship without contracts? I would not do that.” (Aircraft Case Study, Customer)*	Contract with reward / penalty systems & SLA: No information sharing	Supports P1 / partly rejects P2a / partly supports P2
Trust	*“It is always dangerous […] to allow external firms to look into it (information). […] This is not good.” (Retail Case Study, Firm Delta)*	This statement shows the awareness that information improves performance, while the fear of opportunistic behavior is higher.	Supports P4
Trust	*“[…] in a long-term partnership, you have Point-of-Sales data as reference (for forecasting) from the last periods […] that kind of information sharing happens for sure.” (Retail Case Study, Firm Beta); “There are some specific suppliers […]. This [information sharing] depends on the suppliers […].” (Retail Case Study, Firm Beta)*	Partnerships perceived as trustworthy relationships enable mutual information sharing.	Supports P4 / partly supports P5
Trust and contract	*“We will terminate a contract, if someone tries to fool us; otherwise we have no problem to share information and to collaborate” (Tobacco Case Study, Supplier A)*	This statement provides evidence, that bargaining power and contracts are important for the general business relationship, while trust is more important for mutual information sharing in supply chains.	Supports P2b / supports P4
Trust and bargaining power	*“[…] if you share (strategic) information, they (the suppliers) will increase the price.” (Aircraft Case Study, Customer)*	Bargaining power does not help to achieve mutual information sharing; it needs trust.	Supports P4

Table 7 – Excerpt of the Case Study Coding: Contracts and Trust

6.3 Bargaining power and information sharing

We found that bargaining power plays a big role in determining how the firms perceive their relationship with each other, and therefore influences information sharing processes. In fact, many of the statements from our interviewees indicated that firms were actually aware of their own bargaining power, and viewed it as more important than the formal contracts. The role of contracts in securing partnerships is often undermined by either trust or bargaining power. For example, as discussed in the previous section, contracts are often viewed as coercion in the tobacco industry. Findings from the aircraft industry also indicate that the collaboration among supply chain members is largely determined by the usage of bargaining power; while usage of bargaining power resulted in no operational or strategic information sharing. Firms having the stronger bargaining power position use it to improve unilaterally their own performance. Within the aircraft industry, information sharing is determined in the manifest of political games. In this case, however, contracts play a more central role as a safeguard (especially by a firm with a weaker bargaining power) against coercive or opportunistic behavior; being a positive indication towards a trustworthy relationship. We found that in some relationships, more information was shared, although it was not precise and shared only orally.

We found that a better bargaining power position is used to dictate minimum order quantities, causing no information sharing and lower supply chain performance. In contrast, we found that supply chain partners align their supply chain processes towards mutual information sharing, regardless of differences in bargaining power. Therefore, the behavior can either be interpreted as (missing) supply chain knowledge from the buyer (from the supplier) as the stronger firm could increase their own firm performance by defining the rules (Magretta, 1998), or calculated behavior and awareness of the supplier regarding its own bargaining power, given that the supplier also harbors expectations regarding future business (Parkhe, 1993b). Further, we found that in case of stable markets, aligned incentives especially driven by a trustworthy relationship and long-term orientation allow firms to provide services using mutually shared information, and avoid the usage of coercive power as it is perceived as detrimental to the relationship. This results in mutual information sharing and the possibility for firms and supply chain partners to improve their firm and supply chain performance (Dyer & Nobeoka, 2000).

Antecedent	Statement	Remark	Proposition
Bargaining power	*"I am interested in my supply chain until [my] wholesaler. What the others do does not interest me…" (Aircraft Case Study, Customer)*	If firms make use of their bargaining power and act egoistically, no information is shared.	Supports P1
Bargaining power	*The Supplier [Retailer B] has to do what we want." (Aircraft Case Study, Customer)"*	Contracts are used to focus on product price. Bargaining power position of the stronger firm cannot be strengthened. Only transactional information is shared. Political games between the supply chain members prevent information sharing.	Supports P1 / Rejects P2a
Bargaining power	*"The suppliers say if you want to have the drapery in your*	The suppliers have a stronger bargaining power position. However,	Supports P1 / Partly sup-

	color […] then you have to buy a minimum order quantity." (Retail Case Study, Firm Delta)	they do not make use of that position to set rules and initiate information sharing such as forecasts. This behavior results in no information sharing and reflects missing knowledge and capabilities.	ports P6
Bargaining power, trust, information management capabilities, and supply chain knowledge	*"We have defined order minimums and mechanisms to work efficiently with partners. […] we also initiated a regular meeting to share latest developments within the field of supply chain management […]." (Retail Case Study, Firm Beta)*	As firm Beta is the stronger partner it provides evidence on how Beta uses its power to initiate information sharing. Further, as Beta states that they are "partners", it can be interpreted as a trustworthy relationship. This enables both firms to use their information management capabilities and supply chain knowledge to realize mutual information sharing in an efficient manner.	Supports P3 / supports P4 / supports P5.
Bargaining power and trust	*"That [coercive power] would not help any party" (Tobacco Case Study, Retailer B)*	This statement reflects the importance of trust to realize mutual information sharing.	Supports P4

Table 8 – Excerpt of the Case Study Coding: Bargaining power

7 Discussion

Information sharing has been identified as an enabler for supply chain performance in previous research (Fawcett et al., 2007; Straub et al., 2004). However, firms often limit information sharing to a transactional level, and previous findings indicate contradictory attitudes and behaviors towards information sharing among supply chain members (Kampstra et al., 2006; Prokesch, 2010). We explain how different antecedents influence information sharing behavior and develop a matrix to organize the antecedents to illustrate their impact on information sharing in supply chains. In specific, the matrix explains (1) how antecedents are inter-related, and (2) thereby provides a reason for defecting information sharing versus mutual information sharing. Hence, we (3) provide a possibility to relate previous research findings on antecedents on information sharing within one matrix; and (4) complement latest research on dynamic effects on information sharing (Fawcett et al., 2012). We, further, (5) contribute to research by using a different theoretical perspective (game theory) to analyze antecedents on information sharing within the discipline of supply chain management; and (6) by basing our results on case study research allowing breadth and depth of findings/theory (Ellram & Cooper, 2014). Practitioners can use our findings to develop strategies for managing information sharing in supply chains and react appropriately on occurring changes.

Although previous research has used different theoretical perspectives such as transaction cost economics to explain the influence of various antecedents on supply chain performance (Bailey & Francis, 2008; Fawcett et al., 2008a), there is little research explaining inter-dependencies and inter-relations between antecedents and their direct influence on information sharing (Carter et al., 2014; Ellram & Cooper, 2014). Further, previous research analyzed the influence factors of information sharing mostly from a single perspective such as technical knowledge for linking supply chain systems (Barrett & Konsynski, 1982; Rai, Patnayakuni, & Seth, 2006), or opportunistic behavior of partners (Kramer, 1999). Further, findings such as the importance of economic gains for firms seem to be either obvious (T. Davis, 1993; Williamson, 1993) or miss an explanation regarding inter-dependencies with other factors affecting information sharing in supply chains.

We use a matrix that reflects a game-theoretic perspective to explain the importance of antecedents on information sharing, and their inter-dependencies and inter-relations. Based on this perspective, we develop propositions being tested using expert interviews and multiple case studies. In consequence, the matrix allows to identify, to analyze, and to manage inter-dependencies and inter-relations of antecedents on information sharing and firms´ information sharing strategy. For example, our research explains why two supply chains with similar bargaining power differentials among the supply chain partners end up with very different information sharing arrangements. Thereby, we contribute to theory by enabling researchers to organize antecedents from different research streams on information sharing. Further, it helps to develop quantitative research models, especially to derive dependent and independent variables. Besides the organization and explanation of the antecedents on information sharing, the matrix can be used to analyze dynamic effects of antecedents on information sharing by conducting qualitative research.

Our analysis indicated that among supply chain members, differences in bargaining powers increases the propensity to resort to gaming tactics within the supply chain. In particular, we found that firms are likely to use their advantageous bargaining power position to either hold on to strategic information, or demand it from the weaker partner, without reciprocating similarly by sharing their own information. We found that while downstream partners might be aware of the beneficial effects of information sharing on supply chain performance, information is not shared when it is believed to lower the own bargaining power position. Therefore, our results support P1. However, such gaming tactics can often be overcome through the aligned distribution of mutual gains that results in a general willingness to share mutually information being in congruence with previous findings (T. Davis, 1993; Williamson, 1993). Further, our findings indicate that bargaining power can be used to initiate long-term relationships, being influenced positively by trustworthy behavior. In the case of trust, firms shared information mutually. For example, in our retail case study, we found that one of the stronger partners shares operational and strategic information with long-term suppliers, have institutionalized rules and norms, and have established a collaborative planning process. Therefore, our findings provide evidence, that bargaining power and contracts on their own are less important than trust for mutual information sharing in supply chains; thus supporting P3 and P4.

While we found less evidence for P3, previous research revealed that bargaining power can be used to initiate information sharing, either unilateral information sharing or mutual information sharing (Dell, Toyota). However, we found contradictory results on the effect of bargaining power and its impact on information sharing. Based on previous research (Dell), we thought that strong firms use contracts to force their partners to share information. Despite that, we found that contracts could prevent neither opportunistic behavior nor helping firms to strengthen their bargaining power position, while we found that contracts help partners to align monetary incentives. Further, contracts were either used to realize mutual information sharing (validating P2b) or resulted in no information sharing (rejecting P2 and P2a). For example, one firm insisted on contracts (due to their stronger bargaining power position) and behaved opportunistically resulting in no information sharing. For example, interviewees from stronger firms stated that they fear egoistic use of information by the weaker firm to consolidate their positions, e.g., in price negotiations. Therefore, our findings reject P2 rather than accepting it. Our findings therefore reflect that the importance of bargaining power for mutual information sharing is relatively low, while it allows firms to initiate projects. In addition, in case the stronger supply chain partner feared opportunistic behavior, detailed contracts with reward and punishment were in place, resulting in a low level of trust, and no information sharing. These findings reject P2a; even as contracts are assumed to prevent opportunistic behavior by using reward/punishment functions (Gérard P. Cachon & Lariviere, 2005; Williamson, 1989), firms avoid sharing operational or strategic information. Further, it was found that while the stronger partner might rely on contracts to prevent the misuse of strategic information and opportunism by the weaker partner, firms with a weaker bargaining power position often rely on contracts to safeguard themselves against coercive pressures from the stronger partner in the relationship. While this can be interpreted as fear of opportunistic behavior (Fawcett et al., 2006), it also shows that firms are willing to collaborate and share strategic information in case of win-win situations; thus supporting P2b.

Interestingly, we also found that in some cases, the stronger firm might not be interested in collaboration, and therefore not decide upon any information sharing strategies; representing different and varying findings for P2a. As this is generally in contradiction to the notion that firms use their bargaining power positions to negotiate the quantity or nature of information that is shared within the relationship, either unilaterally (i.e., demanding information from the weaker partner) or mutually. Hence, it would make sense to investigate why stronger firms do not make use of the bargaining power position to dictate information sharing as these findings are opposite to previous ones (Magretta, 1998). Further, it was observed that, information sharing behavior is different in case the supplier is the stronger partner. We found that strong suppliers do not set rules for information sharing resulting in no information sharing. This behavior can be explained by expectations of the supplier regarding future business from the customer. However, we also believe that this finding provides evidence for the suppliers´ lack of supply chain knowledge and their missing awareness of how to use their bargaining power position to improve supply chain performance by initiating supply chain projects. Future research should further investigate the expectations of buyers and suppliers in different bargaining power positions incorporating influence factors such as the size of the firm, the industry, or the culture. This would allow researchers to understand the influence of bargaining power and contracts on information sharing in supply chain more in detail.

Our research enhances previous understanding on the use of formal contracts by showing that when formal contracts are used within buyer-supplier relationships, the basic motivation with which the firms approach the whole contracting process might be very different depending on the bargaining power position of the firms and the level of trust in the relationship. This calls for future research on the differential use and relevance of contracts within the supply chains. At the same time, our research indicates that in many buyer-supplier relationships having a long-term orientation, firms often rely on relational contracting rather than formal contracting, as formal contracting is perceived to have a negative connotation, and be reflective of lack of trust. This partly confirms P4 and partly rejects P2. Further, it might be interesting to investigate whether there are industry-specific norms in terms of the use of formal contracting vis-à-vis relational contracting using a quantitative approach.

Furthermore, firms indicated that trust is a necessary condition to share information; even stating that contracts will be terminated as soon as firms betray each other. Moreover, our results indicate that trust improves tasks such as problem solving on a daily base or connectivity of information systems. These findings provide evidence that trust influences information management capabilities of firms and contributes to collaborative building of supply chain knowledge. In consequence, our results support P4 and P5, indicating the inter-relation between the antecedents; especially the necessity of trust to enable information sharing, and the importance of trust to leverage supply chain knowledge and information management capabilities for effective information sharing. Further, our analysis indicated that when firms aligned economic incentives, they often accepted a slight shift in their bargaining power position. This shift could result in a move from unilateral information sharing towards mutual sharing of information; thus supporting P3. This was observable both in the retail industry, as well as in the tobacco industry. In both cases, we found trust as enabler for strategic information sharing, supporting P4. Further, this finding was especially evident in cases, where partners had a long-term orientation, and in the absence of bargaining power. Moreover, the level of trust was aligned by contractual agreements, supporting P2b. Moreover, we found that firms being interested (and knowledgeable) to improve supply chain performance (vs. own firm performance) used their bargaining power and contracts to initiate information sharing projects and thereby establish a trustworthy relationship; thus supporting P2b and P3. In sum, our results provide evidence that trust positively contributes to the relationship by signaling integrity, honesty and a decrease in the risk of opportunistic behavior. Thereby, our results supports P4. This has significant implications for supply chain members, particularly as trust facilitates mutual information sharing, it might not necessarily have an adverse effect on the bargaining power position of the firm.

In addition, data from our cases and expert interviews also highlights the importance of both supply chain knowledge as well as information management capabilities for realizing the highest level of information sharing; thus supporting P6. Previous research has emphasized on the importance of supply chain knowledge (Bailey & Francis, 2008; Hult et al., 2004), in reality, firm employees often lack a thorough understanding of their activities within the chain. While supply chain knowledge helps firms in realizing the value of the shared information, information management capabilities allow firms to integrate their systems and ensure connectivity with partners. Besides connectivity, information management capabilities help to introduce information systems and ensure the quality of shared data. Further, our data provides evidence (and thereby confirms previous research) for trust as enabler to introduce new systems, which heavily impact existing business processes such as the introduction of inter-organizational information systems (F. D. Davis, 1989). In addition, our results provide evidence that information management capabilities of firms help to create confidence in shared information thus indicating a loop between trust and information management capabilities. Future research should analyze this finding more in-depth. Moreover, we found that information management capabilities allow firms to share relevant data in a timely manner, while supply chain knowledge is needed to understand the supply chain processes and their impacts on supply chain performance (supports P6). In addition, we found that firms were able to realize higher (supply chain) performance by building a supply chain knowledge base, training their employees, and thereby creating an awareness for supply chain processes and its financial impact; thus supporting P7.

Our results provide an overview on how firms can achieve mutual information sharing (Table 9): Firms can use their bargaining power position to initiate information sharing projects, and use contracts as mutual commitment towards information sharing. Firm should opt for using contracts to document processes, create long-term orientation, act as problem solver, and define how additional gains are shared. For example, firms can improve their collaboration by defining escalation pyramids for processes. However, if firms use their bargaining power position to improve their own performance and perceive contracts as instrument to establish punishment and reward systems, the level of shared information decreases. Firms having an egoistical attitude can use their bargaining power to set rules for information sharing and contracts to protect against opportunistic behavior from partners.

Despite that, documentation of processes enhances firms and their partners to use their information management capabilities to connect systems by using established protocols such as EDI and thereby reduce transaction costs. This allows firms to improve the data quality and fosters the level of trust among supply chain partners. Long-term orientation and a trustworthy relationship also stimulate supply chain partners to introduce collaboratively new technologies and benefit commonly from its usage by faster return-on-investment rates. Further, firms can strengthen their collaboration by establishing transparency along the supply chain or introducing further instruments such as inter-organizational information systems. This allows partners to plan and steer the supply chain in a collaborative manner. Therefore, if basic issues are documented in contracts, trust enables partners to use their information management capabilities and their supply chain knowledge to realize the highest level of information sharing. In consequence, supply chain partners can define mutual information sharing strategies. This enhances firms to build a broad (supply chain) knowledge base and to develop training programs to improve supply chain knowledge at the employees and management level. Based on our findings, we also assume that supply chain knowledge, in turn, creates trust; stimulating further exchange of information. Supply chain knowledge allows employees to understand the impact of their actions for the firm and from a supply chain perspective. This include not only the information and material flow, but also a financial viewpoint.

In sum, trust moderates the detrimental effects of differences in bargaining power positions, and lowers the need for contracts, while information management capabilities enhance connectivity between systems and improve the quality of shared data. At the same time, the importance of supply chain knowledge cannot be underestimated, since it was found that even though firms in an advantageous bargaining power position are unable to realize the full potential of information sharing and generate higher rents in the absence of sufficient understanding regarding supply chain processes. Table 9 provides an overview of the antecedents on information sharing and their importance for mutual information sharing using our matrix. The game-theoretic setting allows us to explain the necessity of information sharing as the discrepancy between realizing the highest supply chain performance (by mutual information sharing) and having the highest risk to suffer from opportunistic behavior (in case of unilateral information sharing) can be illustrated. Further, the matrix allows to identify inter-relations and inter-dependencies between antecedents on information sharing, and to explain the importance of various antecedents.

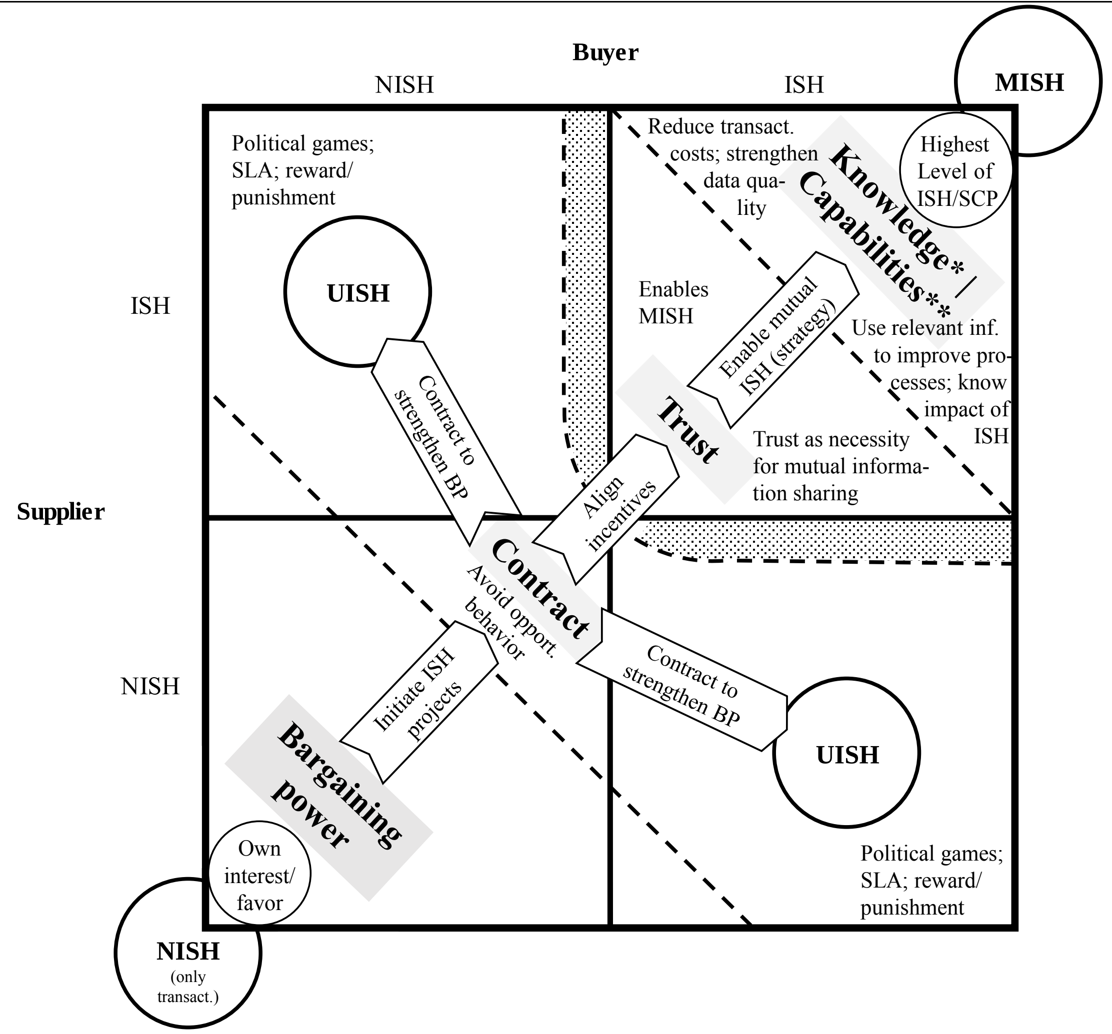

Table 9 – Antecedents and their influence on information sharing

The contributions of this study are the following. In terms of research, it highlights the importance and impact of antecedents on information sharing, while providing some insights regarding factors that create a tension towards information sharing (such as opportunistic behavior), as well as mechanisms to neutralize this tension (such as trust or supply chain knowledge). More specifically, our matrix offers an opportunity to explain contradictory findings from previous research within the field of information sharing in supply chains. Accordingly, we provide a more nuanced understanding of the inter-relations and inter-dependencies of identified antecedents on information sharing, which can be further tested and validated in empirical settings. From a practical perspective, the matrix can be used by firms to design and manage their information sharing strategy by analyzing their supply chain relationships. Further, it will help them in enhancing their performance and consolidating their own position without sacrificing on mutual trust and other factors that hinder the overall relationship. Table 10 highlight the implications for practitioners and researchers, as well as an agenda for future research.

<table>
<tr><th>Practical Implications</th><th>Theoretical Implications</th></tr>
<tr><td>

Alignment of antecedents on information sharing

Trust is more important than bargaining power and contracts to realize mutual performance gains.
Bargaining power can be used to initiate projects, and contracts to align the ratio of economic benefits.

Firms have to create an awareness within their supply chains and among their partners, that defecting lowers the supply chain performance, and thereby a decrease of supply chain competitiveness.
Supply chain partners have to create mechanisms to visualize additional generated gains, and agree in advance on a ratio to share these gains.
A (moderate) shift in a firms bargaining power position is not important in case of long-term orientation.
Long-term oriented partnerships institutionalize rules and norms resulting in mutual information sharing.
Supply chain knowledge: Train employees regarding the processes and the relevance of different information.

</td><td>

Information sharing matrix

New perspective (game theory) to explain inter-relations and dynamics of various antecedents on information sharing linking previous findings.
Provides an explanation on why firms defect information sharing and on how mutual information sharing can be realized.
A well-known problem (prisoners´ dilemma) has been adapted to explain differences in information sharing behavior in supply chain to the discipline of supply chain management.

Bargaining power allows firms to initiate information sharing in supply chains.
Contracts align incentives of supply chain partners; therefore, contracts can be seen as “vehicle” for supply chain collaboration.
Bargaining power and contracts are not sufficient conditions for mutual information sharing.
Trust leverages mutual information sharing.
Supply chain knowledge and information management capabilities are needed to realize the full potential of information sharing.

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<tr><th colspan="2">Agenda for Future Research</th></tr>
<tr><td colspan="2">

As we found, that supply chain knowledge has a positive effect on trust, this relationship should be analyzed further, especially on when there is a reciprocal effect.
Our results on the role of contracts for information sharing in supply chain varied; therefore, future research should analyze (1) the need of contracts for information sharing, (2) the role of contracts from different bargaining power positions of firms and from a supply chain perspective. Investigate the differential usage of contracts its relevance for supply chain relationships and information sharing, and check for industry-specific norms.
As this is a qualitative study, future research should conduct quantitative research on identified inter-relations (1) to confirm the inter-relations, the inter-dependencies, the matrix, and the dynamic effects; and (2) to ensure a proper managerial usage for developing information sharing strategies.

</td></tr>
</table>

Table 10 – Practical Implications, Theoretical Implications, and Future Research

8 Limitations

All research has limitations, and this study is no exception. While theories derived from qualitative research can be seen as essential, valid, and novel theories about specific phenomenon, further empirical testing is needed to ensure a broad manifestation within the researched field (Eisenhardt, 1989).

Case studies do not allow researchers to control events and might capture only contemporary events, while its strengths provides researchers the ability to analyze multiple sources of evidence (Yin, 2009). Further, all the analyzed cases are from different industries. While this facilitates theory validation (Eisenhardt, 1989; Pettigrew, 1990), industry specific influences should be investigated; either in quantitative or qualitative settings. An analysis of supply chains in the same industries could be used to control for cross-industry variations. Further, a longitudinal case study can derive better insight regarding how different antecedents change information sharing over time, and identify factors that moderate this shift.

Quantitative research can further develop our propositions towards hypotheses to solve conflicting statements such as for proposition three and test them for significance by using surveys. Further, quantitative research will allow researchers to generalize the findings and determine significant linkages between the antecedents to address measurement issues.

9 Conclusion

The primary contributions of this research, then, are twofold: theoretical development of a matrix that blends important features from supply chain management with insights from game theory; and providing empirical support for the matrix's propositions by using a two-step research approach by initially interviewing supply chain experts followed by case study research. The findings identify various antecedents such as contracts, bargaining power, or supply chain knowledge that influence information sharing showing the need to analyze information sharing in supply chains from a multiple perspective. We highlight the importance of trust on information sharing and propose effects of supply chain knowledge for realizing the highest supply chain performance. Furthermore, this research gives practitioners and researchers the possibility to gain a better understanding why currently 90% of the firms limit their information sharing processes only to a transactional level (Prokesch, 2010).

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Publication 6

Interdependent Determinants of Supply Chain Information Sharing: Evidence from the Tobacco Industry

Title	Interdependent Determinants of Supply Chain Information Sharing: Evidence from the Tobacco Industry	
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Abstract

Information sharing plays an important role in determining supply chain performance. However, organizations may refrain from sharing information because of concerns regarding opportunism. Different theoretical camps have either espoused the use of contracts to safeguard against opportunism, or the use of trust to reduce the occurrence of opportunistic behavior. In addition, information management capabilities of the firm not only determine information sharing, but also influence how trust develops within the supply chain relationship. However, there is little research addressing the inter-relations between contracts, trust, bargaining power and information management capabilities on information sharing, while it has been found to be inter-related. We address this gap by proposing a research model which relates aspects of trust, bargaining power, contracts and information management capabilities. Our research model is tested using a single explanatory case study from the German tobacco industry. The results indicate that bargaining power, trust and contracts interplay with each other in determining information sharing behavior within supply chains. Further, we found an influence of supply chain knowledge on trust. In consequence, we contribute to a better theoretical understanding on supply chain exchange relationships by blending different perspectives towards a complementary picture of influence factors on information sharing.

Individual contribution from Tobias Engel: For this paper, I contributed by writing all chapters with my co-authors; except chapter 2: here the basics of transaction cost economics, relational exchange theory, and resource-based view were written by my co-authors, while I contributed by writing the text about the antecedents such as bargaining power, information management capabilities, or trust. Further, we developed the interview questions and the coding scheme. Moreover, I contributed by developing the research model, and the hypotheses. In addition, I attended all interviews, analyzed, and discussed the results. The review comments were addressed by me, and I was in charge to submit the new version of the paper.

1 Introduction

Supply chain management initiatives can result in up to 50% drop in inventory levels, almost zero stock-out rates and better net margins (Klein & Rai, 2009; Swink, Golecha, & Richardson, 2010). However, firms are often unable to achieve these improvements due to a lack of information exchange within their supply chains despite recognizing the benefits of information sharing. Existing research indicates that 90% of firms limit information sharing to purely transactional information (Prokesch, 2010).

Previous research indicates the existence of varying information sharing behavior among supply chain members (Jeffrey H. Dyer & Nobeoka, 2000; Magretta, 1998). Reluctance towards sharing information can be explained based on the reasoning that access and control over strategic information allows firms to influence terms and conditions in their own favor (Argyres & Liebeskind, 1999), while a more collaborative exchange relationship can result in the sharing of higher order information that have strategic implications for the supply chain (Jeffrey H. Dyer, 1997). These seemingly conflicting effects towards information sharing call for a more nuanced analysis and understanding of exchange relationships among supply chain members (Kampstra, Ashayeri, & Gattorna, 2006).

Previous research has analyzed information sharing behavior in supply chains using different theoretical perspectives. For example, Williamson (1985, 1993b) suggests that firms in an exchange relationship have an inherent tendency to behave opportunistically using a transaction cost economics (TCE) perspective. In contrast, Macneil (1980) and Uzzi (1997) emphasize on the role of trust as critical to fostering and maintaining value-enhancing interfirm relational exchanges apply the relational exchange theory (RET).

While these two theoretical perspectives have provided significant insights (Goo, Kishore, Rao, & Nam, 2009; Rai, Keil, Hornyak, & Wüllenweber, 2012), in reality, varying factors such as transaction costs (bargaining power and contracts) and factors of relational nature (trust) characterize the supply chain exchange relationships (Kampstra et al., 2006). Further, as supply chain exchange relationships develop and mature, interdependencies among firms are expanded and elaborated (Lewicki et al. 1998), however empirical validation to this assertion has remained sparse (Lado et al. 2008), and relevant items, levels and joint influences affecting supply chain collaboration have not been assessed (Rai, Keil, et al., 2012; Van der Vaart & van Donk, 2008). We address this gap by analyzing the interplay between barganing power, contracts, and trust in the context of supply chain exchange relationships using a qualitative approach.

In addition to TCE and RET, the role of information management capabilities of the supply chain members have been highlighted in explaining information sharing behavior within the relationship (Sunil Mithas, Ramasubbu, & Sambamurthy, 2011; Rai, Patnayakuni, & Seth, 2006). This stream of literature is based on the resource based view (RBV) which describes firms as a combination of resources and capabilities (Amit and Shoemaker 1993). Based on this perspective, information management capabilities of firms in a supply chain relationship ensure accuracy and timeliness of information, and therefore contribute towards the quality and effectiveness of information sharing (A. Malhotra, Gosain, & El Sawy, 2007). However, it is still not clear how other factors from TCE and RET jointly affect information management capabilities and therefore the information sharing behavior in supply chain collaborations (Kampstra et al., 2006; Rai, Pavlou, Im, & Du, 2012).

Using positivistic case study approach, we analyze differences of information sharing behavior among various members of a tobacco supply chain based on differences in the information management capabilities, and differences in bargaining power, contracts, and trust. This allows us to analyze how factors from TCE, RET and RBV conflate and affect information sharing in supply chain relationships.

The rest of the paper is organized as follows. The next section provides the theoretical background of our model linking the variables of interest. This is followed by a description of our research methodology. We then present the case information and discuss the findings. We conclude by discussing the implications of our findings and the contributions of this research.

2 Theoretical Background

As previous research argued that collaborative relationships are susceptible to failure due to various organizational and behavioral influence factors, and empirical research needs to expand its scope beyond its traditional confines (Emberson & Storey, 2006; Rai, Pavlou, et al., 2012), we draw from transaction cost economics (TCE), relational exchange theory (RET) and the resource based view (RBV) to develop our research model.

2.1 Information sharing

Previous literature has emphasized the role of information (achieved through sharing) in the management of supply chains (H. L. Lee, Padmanabhan, & Whang, 1997, 2004). Sharing operational and strategic information allows firms to improve the supply chain performance, while the sharing of transactional information is a necessary condition to organize the exchange of goods (Seidmann & Sundararajan, 1997). More importantly, additional rents can be generated by strategic information sharing (Cachon & Swinney, 2011; Klein & Rai, 2009). In order to realize additional rents, the shared information have to be accurate and relevant, and supply chain partners need to have the capabilities to take necessary actions based on the information to improve performance (Goswami, Ravichandran, Teo, & Krcmar, 2012; Wang & Wei, 2007).

Despite the potential for higher profits, strategic considerations may prevent firms from collaborating and mutual information sharing (H. L. Lee et al., 1997). Firms may choose not to share information when it is perceived that partners may use information asymmetries as competitive advantage to increase their rent. This is especially true when relationships are more opportunistic and/or purely transactional (Argyres & Liebeskind, 1999; Nair, Narasimhan, & Bendoly, 2011). In practice, many firms either purposefully avoid information sharing or are not capable of varying the factors the influence information sharing (Prokesch, 2010). For example, isolated specific behavior of firms often results in a tit-for-tat strategy causing lower rents (Axelrod, 1984). Firms experiencing operational inefficiencies often establish several actions such as information sharing and contractual safeguards to counter such behavior (Mason-Jones & Towill, 1997).

2.2 Transaction cost economics

The costs incurred with making economic exchange are referred to as transaction costs. Hence, they are the costs of participating in a market. Transaction costs can be distinguished in three categories: search and information costs, bargaining costs, and policing and enforcement costs (Dahlman, 1979). The first category includes all the costs that are associated with searching for the required good and finding the lowest price. The second category resembles costs that are incurred with coming to an acceptable agreement with another party. The third category includes those costs that come with monitoring and enforcing the compliance with contractual agreements (Dahlman, 1979).

With regard to information sharing in supply chains, contracts and bargaining are of particular interest due to the long-term relationship of the parties and the transaction costs incurred with coming to an agreement on the extent and mode of information sharing. Search and information costs can be disregarded at this stage, as the objective of supply chains is to reduce these costs by establishing long-term relationships with preferred partners. Also, enforcement costs are disregarded here as this is more a governance issue than an information sharing issue.

Contracts

The aim of a contract is to guide the behavior of partners towards desired objectives (Goo et al., 2009). From a contractual perspective, the influence of bargaining power, contracts, and supply chain partnerships on information sharing has been analyzed (S. Mithas & Lucas, 2010; Williamson, 1989). The analysis of bargaining power and inter-relational dependencies among supply chain members allows to study situations such as supply chain specific investments (Nair et al., 2011), the behavior in supply chains with exit options and decentralized supply chains (Berstein & Federgruen, 2005). Furthermore, if transactions are long-term oriented, commitment and flexibility in agreements play a major role (Cachon & Lariviere, 2005), attracting partners to share information, and make performance-enhancing investments (Liker & Wu, 2000).

In addition, Rai, Keil, et al. (2012), Goo et al. (2009) and Kim and Mahoney (2006) studied the relation between contractual factors and relational characteristics. However, their research either focuses on relation specific information technology (IT) systems (Kim & Mahoney, 2006) or IT outsourcing relationships (Goo et al., 2009; Rai, Keil, et al., 2012). Further, in respect to their findings, their results are derived within different fields (outsourcing vs. supply chain information sharing) and therefore cannot be easily adopted to supply chain collaboration as assessed items and their levels might not be appropriate for information sharing in supply chain relationships (Van der Vaart & van Donk, 2008). Additionally, Rai, Keil, et al. (2012) propose to verify their findings using a longitudinal approach. This allows us to analyze, reflect, and control for dynamics in supply chain relationships (Fawcett, Fawcett, Watson, & Magnan, 2012).

Bargaining Power

Bargaining power refers to the ability of a party to exert influence over another party. In supply chains, bargaining power has been analyzed in various settings using different perspectives of information sharing, incentive alignment and power-relational aspects (Nair et al., 2011; Steckel, Gupta, & Banerji, 2004). Furthermore, the influence of investments on bargaining power and inter-firm relationships has been studied (Nair et al., 2011). Moreover, buyer-supplier relationships have been modeled as games with cooperative and non-cooperative behaviors (Esmaeili, Aryanezhad, & Zeephongsekul, 2009). Subramani (2004) suggests, that strong firms make use of their bargaining power position and introduce new supply chain management information systems to leverage their supply chain performance. Additionally, it has been investigated how contracts influence information sharing and improve information sharing processes such as forecasts or inventories (Cachon & Lariviere, 2001). Further research related to bargaining power focuses on supply chain coordination through revenue sharing (Cachon & Lariviere, 2005) and the usefulness of contractual safeguards for inventory policies to minimize supply chain costs (Cachon & Zipkin, 1999)

Although the general willingness of firms to engage in supply chain information sharing initiatives can be realistically assumed, firms may focus on increasing (unilaterally) their profits (Argyres & Liebeskind, 1999; Nair et al., 2011). Information as a resource of power is often tightly controlled within firms and among supply chain partners; this prevents information sharing processes, especially in the absence of trust in supply chain relationships (Fawcett, Ogden, Magnan, & Cooper, 2006). Therefore, the form of power – reward power, coercive power, expert power, referent power and legitimate power – over information needs to be regarded (French & Raven, 1959), as it influences aspects such as punishment or reward in supply relationships (Maloni & Benton, 2000).

2.3 Relational exchange theory

Relational exchange theory (RET) emphasizes the role of social exchange mechanisms including relational governance (Poppo & Zenger, 2002), socialization (Wathne & Heide, 2000), trust (Poppo, Zhou, & Ryu, 2008), and psychological contracts (Ring & Van de Ven, 1994). Social exchange, describes interactions among individuals creating obligations that, under certain circumstances, lead to high-quality relationships (Emerson, 1976). These interactions are interdependent and contingent on the actions of another person. In contrast to economic exchange, social exchange entails unspecific obligations that cannot be bargained. Hence, social exchange engenders feelings of personal obligations, gratitude and trust (Blau, 1964). Trust is considered as an outcome of favorable social exchange. Thus it is important for understanding exchange (Blau, 1964). In contrast to TCE, advocates of relational exchange theory (Macneil, 1980; Uzzi, 1997) emphasize trust as a critical determinant for developing and maintaining value-enhancing relational exchange.

Trust

Trust is defined as “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party” (R. C. Mayer, Davis, & Schoorman, 1995). Hart and Saunders (1997) described that trust is based on fair behavior among supply chain members and a sense of reciprocity, but this does not imply that (economic) outcomes will be equally divided between supply chain members. According to Giguere and Householder (2012, p. 22f) the level of information sharing is more dependent on trust than on information management capabilities of firms. Furthermore, the importance of trust for supply chain relationships grows as the number of supply chain members increases. This is especially true in cases where personal and emotional feelings are involved and decisions have to be made with incomplete information (Komiak & Benbasat, 2004). In addition, trust can be seen as substitute for contracts, reflecting the importance for supply chain relationships (Rai, Keil, et al., 2012). Further, in case of a trustworthy relationship, aspects such as the efficiency of problem solving, better communication among the partners or the momentum for change increase on an operational and strategic level (Fawcett et al., 2012).

Trust strengthens supply chain relationships, motivates firms to idiosyncratically invest into long-term relationships (Doney & Cannon, 1997), reduce uncertainty and risks (Alvarez, Barney, & Douglas, 2003) and fosters satisfactions (Zaheer, McEvily, & Perrone, 1998). Moreover, trust allows firms to reduce the complexity of relationships by eliminating dispensable processes, such as the justification of decisions (Kramer, 1999). According to Morgan and Hunt (1994), trust based supply chain relationships can be characterized by shared values such as sharing common goals, behaviors and policies. More specifically, trust determines participation and involvement in joint decision making and setting mutual commercial goals that contribute to a successful partnership (Dwyer & Oh, 1988).

2.4 Resource based view

The resource based theory (RBV) of the firm describes organizations as sets of resources and capabilities. Resources are tradable knowledge, financial or physical assets that are converted into products or services owned or controlled by an organization. In contrast, capabilities are firm specific processes being tangible or intangible and based on information (Amit & Schoemaker, 1993). Similarly, Helfat et al. (2008) describe capabilities as “the capacity to perform a particular task, function or activity”. RBV argues that organizational performance is described as a function of competitively distinct organizational resources and capabilities (Amit & Schoemaker, 1993). Capabilities are valuable if they are organization-specific, rare and difficult to imitate or substitute (Barney, 1991). Hence, supply chain performance is influenced by the availability of certain resources and capabilities. Variance in supply chain performance can thus be explained by an insufficient availability of resources or different levels of proficiency for certain capabilities.

While previous research revealed the importance of information management capabilities and further related aspects such as supply chain knowledge for information sharing (Fawcett, Magnan, & McCarter, 2008; Hult, Ketchen Jr, & Slater, 2004), only little research has been conducted to analyze the inter-dependencies between information management capabilities, its factors, and other aspects from RET and TCE. For example, Rai, Pavlou, et al. (2012) found that information management capabilities are positively related to value creation, however, their findings are limited as dynamic effects such as the effective usage are not captured. To ensure the inclusion of dynamic effects, Fawcett, Wallin, Allred, Fawcett, and Magnan (2011) propose to analyze longitudinal data using case studies or survey research reflecting two different time periods. Therefore, we focus on analyzing the effect of information management capabilities on information sharing, and its inter-dependencies with other factors from TCE and RET using case study research.

Information Management Capabilities

Information management capabilities are rooted in the resource-based view (Mata, Fuerst, & Barney, 1995), and have been defined as “the ability to mobilize and deploy IT-based resources in combination or copresent with other resources and capabilities.” (Bharadwaj, 2000). Although, availability itself does not contribute significantly to a supply chain´s competitive advantage, firms often use electronic data interchange (EDI) standards and information technology, including EDI-enabled cash registers, resource planning systems and supply chain optimization tools suggesting the importance of technical systems (Goswami, Engel, & Krcmar, 2013). This suggests that information management capabilities, especially technical aspects, play a significant role for supply chain performance (K. J. Mayer & Salomon, 2006). In addition, Fawcett, Osterhaus, Magnan, Brau, and McCarter (2007) argue that reducing information sharing to its technical aspects is not sufficient. Hence, information technology that technically enables information sharing is a necessary, but not sufficient requirement for information sharing across supply chains. To materialize on investments in information technology, information management capabilities are required.

Information management capabilities include technical capabilities that foster the utilization of information technology (Bharadwaj, 2000; Tippins & Sohi, 2003), such as how to implement EDI across the supply chain or the ability to use supply chain optimization tools effectively (Bailey & Francis, 2008; Kumar, 1996). Further, previous findings show that firms outsource activities in the presence of weak capabilities, and use contracts to safeguard against miscellaneous hazards such as missing information management capabilities (K. J. Mayer & Salomon, 2006). While these findings relate information management capabilities with TCE, and explain the avoidance of information sharing with uniqueness of capabilities, more research is necessary to validate these results in the field of supply chain information sharing (K. J. Mayer & Salomon, 2006).

In addition, Kang, Mahoney, and Tan (2009) note that activities may be inter-dependent and are related to other influence factors such as learning. Therefore, we propose to complement technical capabilities with supply chain knowledge. Only with the knowledge of the supply chain, right tools can be selected, the required information to share can be identified and the best process for information sharing can be established (Goswami et al., 2012; Hult et al., 2004). However, as firms handle the exchange of information differently, and differences in information sharing behavior result in varying supply chain performance, a fine-grained understanding of information management capabilities and its antecedents is required to examine the effect on information sharing (Sunil Mithas et al., 2011; Rai, Keil, et al., 2012).

3 Research Framework

3.1 Contracts and information sharing

Contracts, whether formal or informal, are a common way to create a safe relational basis for two or more firms (Poppo & Zenger, 2002). Through a contract it is possible to enforce a reward or penalty system that acts as incentive for involved supply chain members to ensure collaborative behavior. Accordingly, a contract can be seen as safeguards for supply chain specific investments (Cachon & Lariviere, 2005; Williamson, 1989). Furthermore, contracts ensure cooperative behavior, lower the risk of suffering from opportunistic behavior from the partner (either supplier or buyer) and losing strategic valuable information (Klein & Rai, 2009, p. 736). Ghosh and Fedorowicz (2008) found that even though partnering firms may agree on responsibilities and information flows informally written down in a business plan, both firms intended on signing a contract to minimize opportunistic behavior.

While this finding shows that contracts ensure information sharing by formally mandating it, (Rai, Keil, et al., 2012) found that relational factors (trust) can complement and/or substitute contracts. However, previous research did not investigate dynamic effects on the inter-play between contracts and trust for the resolution of conflicts. Accordingly, we can hypothesize:

H1.1:If information sharing is specified in a contract, then information will be shared in order to avoid contractual penalties.

H1.2:In case information is not specified in the contract, informal solutions (on an operational level) avoid contractual penalties, and increase the level of trust.

H1.3:In case of bargaining power discrepancy (strong/weak) among supply chain partners, information sharing will be specified in contracts.

3.2 Bargaining power and information sharing

Bargaining power has an impact on trust, contracts, supply chain specific investments and information sharing (H. L. Lee et al., 1997, 2004; Straub, Rai, & Klein, 2004). Bargaining power discrepancies can explain the difference in the amount to which partners invest in supply chain specific applications. A particularly interesting implication of this is that the stronger partner can realize an obvious benefit by doing a small investment (Ghosh & Fedorowicz, 2008; Klein & Rai, 2009). The stronger partner may fear losing his bargaining power position by sharing operational and strategic information and anticipate opportunistic behavior from his partner, resulting in a less beneficial situation for the stronger partner (Axelrod, 1984; Lave, 1962; Parkhe, 1993). A contract can simultaneously safeguard against the shift of bargaining power, and improve the information sharing behavior against avoidance of information sharing towards mutual information sharing (Seidmann & Sundararajan, 1997).

Maloni and Benton (2000) showed that coercive use of bargaining power would harm long-term relationships, whereas strengthening relational-trust impacts contract design. A higher relational-trust level increases the importance of relational-contracting, as shared norms and values are more important than strict and explicit formal contracts (Jeffrey H Dyer & Singh, 1998; Rai, Keil, et al., 2012).

H2.1: A partner who has high bargaining power fears losing his bargaining power position by sharing operational and/or strategic information.

H2.2: A partner may use his bargaining power position in favor of increasing trust, rather than formally specifying information sharing in a contract.

H2.3:In case of a weak bargaining power position, firms are dependent on the willingness of the stronger firm to establish improvements such as information sharing.

3.3 Trust and information sharing

In the presence of trust, partners interact with each other with lower concerns regarding opportunistic behavior or the loss of strategic information (Morgan & Hunt, 1994). An example is the transmission of Point-of-Sale data from a retailer to a wholesaler and manufacturer to reduce inventories along the supply chain without formal contracts (Steckel et al., 2004). We believe that the dimensions and form of trust influence the amount and quality of shared information in situations where opportunistic behavior of one partner can be imagined or predicted (H. L. Lee & Whang, 2000). Transactional information is shared in cases of calculative trust, while operational information such as forecasts are shared if additional economic benefits can be realized (Ghosh & Fedorowicz, 2008). The importance of trust in supply chain relationships increases in case of asymmetric information and differences in bargaining power among the supply chain members. Asymmetric information and uncertainty are conditions where relational-trust is crucial for supply chain relationships in order to realize mutual information sharing (Agarwal, Shankar, & Tiwari, 2007, p. 447; Svensson, 2001, p. 434 f).

Gulati (1995) and Poppo and Zenger (2002) argue that complementary relational and contractual mechanisms are existing. For example, a higher level of trust results in higher order information sharing such as inventories, stock-out situation or more efficient production planning (Fawcett et al., 2006; Swink et al., 2010). Further, in the presence of trust, organizations substitute formal contracts with trust, resulting in less specified contracts, positively reducing the overall transaction costs among supply chain partners (Rai, Pavlou, et al., 2012). Further, contracts can also lead to mistrust in exchange relationships causing (instead of protecting from) opportunistic behavior (Ghoshal & Moran, 1996). This calls for a more nuanced understanding towards the inter-dependencies of relational and contractual factors. This leads us to hypothesize:

H3.1: Trust has a positive relationship to information sharing.

H3.2:The higher the level of trust, the fewer specifications are made on information sharing in contracts.

H3.3:In case of a high level of trust, contracts are sensed as threat, respectively mistrust, and result in a lower level of information sharing.

3.4 Information management capabilities and information sharing

Information sharing is influenced by information management capabilities. These can be considered a higher order capability that is made up of technical capabilities as well as knowledge regarding the supply chain (Sunil Mithas et al., 2011; Rai et al., 2006). Technical skills are a precondition for information sharing, since it ensures aspects such as data quality, linkage of information systems, and therefore can be seen as base for (electronic) sharing of information (S. Mithas & Lucas, 2010, p. 5; Rai et al., 2006). Supply chain knowledge allows firms to positively influence supply chain processes such as sharing inventory information. Sharing relevant and timely information allows firms to impact the performance of the supply chain by, i.e., optimizing the distribution of goods or improve the efficiency of production planning (Goswami et al., 2012). Further, supply chain knowledge increases information sharing behavior leading to positive effects on supply chain performance by shortening cycle times along the whole supply chain (Hult et al., 2004). Accordingly, the level of shared information is influenced by supply chain knowledge.

According to Kiely and Armistead (2004) customers expect customized services such as automatic alert notification in case of deviation from planned processes; and a sufficient range of technical possibilities such as EDI and XML to link information systems. Therefore, providing customers with diverse and innovative information management capabilities will lead into competence trust. A similar trust effect can be assessed on providing high quality information towards supply chain partners to independently create knowledge from shared information. This highlights the importance of supply chain knowledge on the buyer and supplier side, as the process from data towards information and further to knowledge can be seen as essential for supply chain performance (Arvind Malhotra, Gosain, & El Sawy, 2005). For instance, sharing knowledge about products and processes allows firms to optimize production efficiency and influence inventories (Hult et al., 2004). We hypothesize:

H4.1:High information management capabilities positively influence the relevance, amount and quality of shared information.

H4.2: High information management capability influences trust positively.

3.5 Other variables

In addition to the constructs considered in our research model, we also analyze *product lifecycle*, and *firm size*, which are often considered influential for supply chain management and are therefore likely to affect information sharing in supply chains. Figure 1 summarizes the determinants of information sharing as drawn from transaction cost economics, relational exchange theory and the resource based view.

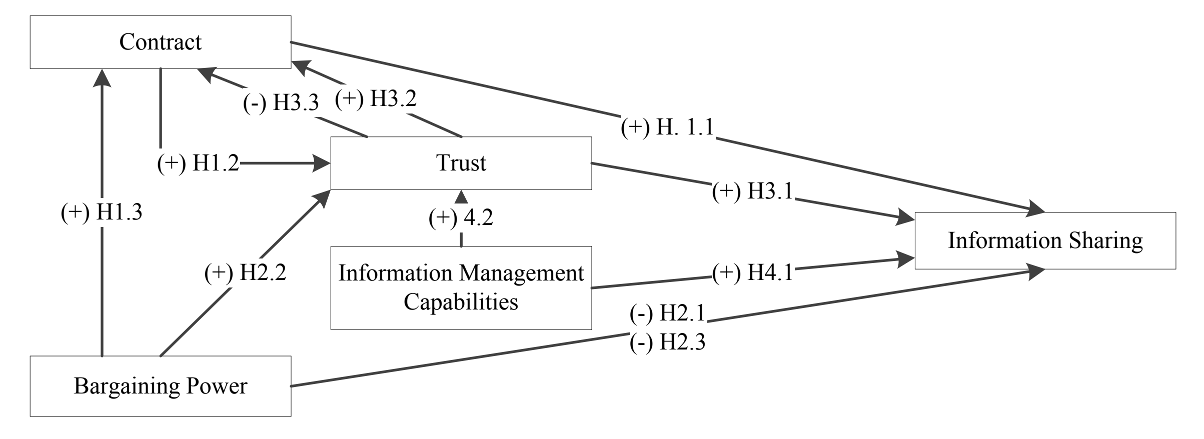

Figure 1 – Determinants of information sharing

4 Research Method

4.1 Sample and Context

For this study, we followed a staged research approach. Therefore, we reviewed the literature to derive antecedents of information sharing and conducted first explorative interviews with six supply chain experts. These helped us to improve our understanding about dynamics in supply chains and the inter-relation of organizational, technological, and political aspects. The analysis allowed us to derive first insights for explaining why supply chain partners avoid information sharing. In an iterative manner, we reviewed the literature to integrate our findings with theory and develop a research framework. Next, we tested our research model using an explanatory embedded single-case study (Yin, 2009). The unit of analysis is the tobacco supply chain, which was chosen due to its low demand and low supply uncertainties. Under such stable conditions supply chain strategies focus towards enhancing efficiency in order to provide the product to the customer in the lowest cost.

Within stable conditions, it can be assumed that there are no differences. However, we identified polar supply chains to provide us with the possibility to analyze the phenomenon under consideration more effectively; as it tends to be more evident than in similar contexts (Eisenhardt, 1989; Pettigrew, 1990).

For the case study, we identified a German mid-sized tobacco wholesaler allowing us to interview retailers, cigarette suppliers and to analyze vending machines. In the upstream supply chain, we selected three different tobacco-product suppliers, each big- (Supplier A), medium- (Supplier B) and small-sized (Supplier C) with regard to their market-share. In the downstream supply chain, we selected one retailer with an EDI-enabled cash register (RetA) and one with a manual cash register (RetB); both located in one of the biggest cities of Germany. Furthermore, we analyzed tobacco vending machines (in possession of the wholesaler) comparing EDI-enabled machines (VendA) with non EDI-enabled machines (VendB). The wholesaler is a family-owned mid-sized company with 150 employees, being the market leader within an area of South Germany. The analyzed tobacco supply chain includes three cigarette manufacturers (referred to as suppliers), one wholesaler, two retailers, and two groups of cigarette vending machines (see Figure 2). Due to data-protection, the participants are kept anonymous.

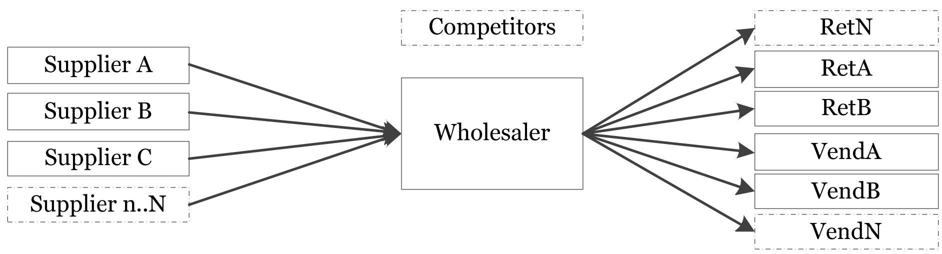

Figure 2 – German Tobacco Supply Chain

4.2 Data

For the explorative interview series, we conducted six interviews with supply chain management experts. These experts were identified from personal networks and chosen for their supply chain responsibility within their firm, and based on their experience. The interviews were conducted in 2011, between September and December. Each interview lasted between 45 minutes to one hour. For the case study, we chose the suppliers, customers, and machines based on comparability aspects and technological influences referring to information sharing, while we ensured polarity. In the upstream supply chain, we conducted interviews with employees from the Sales-, Purchase-, IT- and Logistics-department. Downstream, we interviewed the owners of the retail shops and analyzed the information on the vending machines, acquired from the wholesaler. Altogether, we conducted 15 interviews lasting approximately 1.42 hours on average. We also analyzed the up- and downstream contracts between the wholesaler, its suppliers, and customers. For the interviews, we developed a semi-structured interview guideline covering the fields of trust, contracts, information management capabilities, bargaining power, and information sharing, considering the guidelines from M. D. Myers and Newman (2007). The interview guideline has been derived from literature, and incorporates findings from our explorative expert interviews. Additionally, we executed a pre-check with four supply chain management experts, and two independent researchers not involved in this research. Additionally we reviewed further case material such as material and information flows, revenues and stocks of inventory.

No.	Entity	Role	Type	Duration
1	Supplier A	National Key Account Manager, Logistics Manager, Business Analytics (Employee)	1 Group Interview	5.5 hours
2	Supplier B	National Key Account Manager, C&TM Operations Customer Service & Logistics Manager, Sales Information Systems Manager, Supply Chain Manager	1 Group Interview	5 hours
3	Supplier C	IT Manager, Manager Marketing & Logistics (Vice President), Regional Account Manager	3 Personal Interviews	2.5 hours
4	Wholesaler	Owner, Sales Manager and Sales Employee, Logistics Manager and two Employees from the Logistics Department, IT Manager, Distribution Manager (Vending Machines)	8 Personal Interviews	6 hours
5	RetA	Owner	1 Personal Interview	1.25 hours
6	RetB	Owner	1 Personal Interview	1 hour
7	VendA		Own Analysis	
8	VendB		Own Analysis	

Table 1. Overview of interviewed and analyzed entities for the case study

The interviewees were chosen for their knowledge and responsibility for their firm´s supply chain management. All interviews were undertaken personally at the respective sites and took place between March and April 2013. The interviews lasted between 1.5 and 6 hours. Most interviews were audio-taped and transcribed. In cases where this was not allowed, both interviewers took independent notes. In order to clarify statements, which were either unclear or in conflict with the documents, we conducted follow-up conversations with three interviewees in the downstream supply chain via E-Mail and phone. The described process allowed us to reach saturation, giving us the confidence in our results as no additional critical enrichment of our data could be achieved (Eisenhardt, 1989; Yin, 2009).

4.3 Data analysis

We analyzed our data in an iterative fashion. Therefore, we developed a data structure by traveling forth and back between data from our expert interviews and case study results, resulting in an emergent structure for validating our research model (Locke, 2001; Michael G. Pratt, 2009; Strauss & Corbin, 1998).

In a first step, we developed theoretical dimensions from literature using a top down process (Locke, 2001). The theoretical dimensions were used as base to develop a structure and questions for the interviews. Based on the first interviews, we validated and enriched the theoretical dimensions, formed provisional categories and some initial first-order codes by applying a bottom up open coding process (Locke, 2001; Michael G Pratt, Rockmann, & Kaufmann, 2006; Strauss & Corbin, 1998). By moving from open to axial coding, common statements were used to consolidate categories and align our theoretical dimensions (Locke, 2001; Strauss & Corbin, 1998). This process allowed us to create a data structure with theoretical dimensions, theoretical categories, and first-order codes. We identified inter-dependencies using an induction and deduction approach for revisiting the data in a second step (Locke, 2001; Michael G Pratt, 2008). In a second step, we tested the initial findings by conducting case study research. The interviews were independently coded and analyzed by three researchers. Rival explanations were resolved in group-discussions among the authors, and the analysis of documents and observations (Krippendorff, 2012, p. 13; A. S. Lee & Baskerville, 2003; Yin, 2009). By following this process, we ensured to comply with the quality criteria for case studies suggested by Yin (2009). In a third step, we aggregated our findings towards listing influence factors on information sharing and their inter-relations. This allows us to explain how different factors (incentives) need to be aligned in order to affect information sharing. Further, the approach of going forth and back enhanced us to specify the fit/misfit with our research model, and to ensure a broad theoretical scope, and the analysis of real-world data.

5 Results of the case study

5.1 Use of contracts

By analyzing the business relationship between wholesaler and retailers we did not find any contracts, neither for information sharing nor for other purposes. RetA mentioned that he would view a contract as coercion and he would terminate the business relationship because this is not usual in the tobacco industry. This was emphasized through the quote: *"I work with, with whom I want"*, but if contractual binding is needed, *"absolute price-transparency has to be given"*. The contracts between the wholesaler and the suppliers define that information has to be shared, but no further clarifications are made. This behavior is reflected in the statement from Supplier C, that *"reality changes faster than contracts"*, so it is not seen as a good practice to describe information sharing in contracts in detail. In case of missing information or wrong information, both parties – supplier and wholesaler – solve that issue on an operational level. We found that this is grounded in a trustworthy relationship reflecting long-term orientation. Further, it was reported by the wholesaler, that formal contracting was not done in the past, agreements were only made informally. This sometimes resulted in misunderstandings, but this process also improved the mutual level of trust.

Suppliers have direct contracts with the wholesalers, but also directly with the retailers. Contracts between suppliers and retailers focus on positioning products in store shelves for marketing purposes. In addition, purchasing obligations for new products have been contracted only between Supplier A and the retailers. For transmission of marketing related information, suppliers contract the wholesaler to transmit these information in an anonymous form from the retailers to the suppliers. The wholesaler supports the control process via automatic transmission of sell-in data which are received from the retailers. Supplier A and B have contracts with the wholesaler about the distribution of appointed products in vending machines. These contracts are negotiated yearly, allowing partners to add further aspects. Furthermore, Supplier A has contracted the distribution of promotional poster in vending machines, while the other two suppliers contract the wholesaler to promote their products towards the retailers. Moreover, sales data from promotions are transferred to suppliers, as agreed on in contracts. Additionally, marketing actions with yearly volumes are defined in the contract between the wholesaler and Supplier B and C and can be spread flexibly over the year in mutual agreement. Interestingly, the contract with Supplier C does not precisely specify all details and is less formal.

5.2 Bargaining power

The distribution of power in the German tobacco supply chain is strongly connected to the high amount of distribution points. A retailer can buy products from different vendors such as superstores. Supplier B stated, that consumers have *"less willingness to change their cigarette brand"* and the demand in the *"German market is relatively stable"*, reflecting their strong bargaining power position. However, retailers experience a higher volatility than suppliers as consumers can change their supply point for no transaction costs. The wholesaler has the weakest bargaining power position, as he only trades and further distributes the tobacco products. However, the wholesaler has a strong position in case of the vending machines. RetA told us he would not concentrate all his supply to one wholesaler, as he believes that in monopolistic situations, the margin will shrink; however, RetA does share operational and strategic information (such as inventory) even without a contract, while limiting the transparency to the scope of each specific wholesaler. Similar, Supplier B noted that the usage of coercive power *"would not help any party"* and harm the relationship.

In the relationship that Supplier A and Supplier B has with the wholesaler, we found an asymmetry of rewarding capabilities. The wholesaler reported that getting rewards from the suppliers is currently important from a financial perspective. Rewards can be earned for promotions and for the distribution of designated products in vending machines. Supplier A told us, there is no penalty for the non-fulfillment of contracts. However, in context of an economic dependency, non-rewarding would be viewed as a punishment by the wholesaler. The wholesaler reported that in the yearly negotiations with suppliers, strong bargaining power is often used to argue towards lower rewards for the distribution of products in vending machines. However, the wholesaler can sell small portions of contracted distributions in vending machines to other suppliers to reduce the negative economic impact. Further, the wholesaler mentioned, that *"the smaller the market-share [from suppliers], the more customer-friendly the negotiations are"*.

5.3 Role of trust

The wholesaler told us that trust is strongly connected to a person, reflecting the reason to share strategic information such as about market observations. Therefore, the personal connection towards retailers and suppliers is seen as important factor to gain trust and enables the exchange of richer information. Further, trust was defined as integrity, honesty, flexibility and the behavior in case of problems. Relational trust has been named as most important form of trust for information sharing and business relationships. Further, calculative and competence trust could be also identified as important. In contrast, RetA and Supplier A indicated, that achieving an economic benefit is the goal of every firm, therefore a *"win-win-situation"* always has to be given, independent from information sharing. In consequence, opportunistic behavior is seen as a reason to cancel the relationship by all interviewees. RetA told us, that an example for such a behavior would be the slow reduction of his margin, hidden by increasing tax. Further, RetA stated that a contract results in a lower level of trust, respectively a low level of information sharing. Supplier A stated, that *"We will terminate a contract, if someone tries to play foul with us"*. According to this, information sharing is an important aspect to show openness and honesty and positively affects trust.

In addition, Supplier C reported that trust makes it easier to accept less precise contracts, perceived as a trade-off between trust and preciseness of contracts. This is especially true, as informal mechanisms, rules and norms have been developed over time. The building of trust emerges over time and is always seen as a long-term development, that is enforced by positive experiences in different ways. Supplier A, B and RetB named the handling of problems as driving force for a continuous trust-creation process. Further, for Supplier B trust development can be facilitated by joint events, business communication, flexibility, and trust in advance. Supplier C named the joint sales-action planning as example, while RetB experienced trust as service to re-schedule delivery-dates. Furthermore, RetA reported, that if some products run out of stock on his site he can rely on unscheduled delivery. The wholesaler confirmed this, as this ensure satisfaction of retailers.

5.4 Information management capabilities

Supplier A and B use SAP as ERP system, while Supplier C and the wholesaler use their own application. Our results indicated good information management capabilities from a technical perspective at the wholesaler and supplier side. Use of EDI is seen as an advantage towards efficiency, although, either the EDI is still being planned to be introduced (2013), or some functionalities such as EDI orders are missing. Sell-in data from the retailers are aggregated by the wholesaler and automatically transferred via FTP as CSV file to Supplier A. The wholesaler manually creates promotional reports, which are individually programmed and can be quickly adapted to individual requirements. These reports include location specific information about sold products, additional knowledge from the wholesaler and are characterized by high data accuracy. This has been reflected as competence trust between the suppliers and the wholesaler. However, Supplier B told us, that sharing of POS or inventory levels would not have any effects, because production plans are made 2 month in advance, reducing the flexibility to adapt plans. This holds true for other suppliers as well. The main advantage of information sharing is seen for marketing campaigns.

RetA orders from the wholesaler using an electronic cash desk and receives an electronic delivery note. The data is transmitted via a CSV file to a FTP-Server. The file contains transactional order information of products. According to the wholesaler, one customer cancelled electronic orders indicating that this retailer feared too much transparency. However, RetA reported to be more efficient with the automatic cash desk. From the wholesalers´ perspective, electronic orders reduce manual work, increase efficiency, and bind retailers to some extent. RetB orders via Fax using a standardized form from the wholesaler; the delivery note is the actual invoice. RetA initially defined a minimum stock level, which is now being processed by the automatic cash desk, while RetB plans the stock according to experiences and personal talks with customers. While we could not find differences in the quality of exchanged information, it got obvious that information management capabilities are important to coordinate supply chains more effectively and efficiently, especially in case of high amounts of data. Here information management capabilities reduce time consuming tasks, and ensure the quality of shared information by reducing media disruptions.

The VendA is connected through a GSM module with the vendor, and information is transmitted from the vendor to the wholesaler via VPN. The technical status and sales figures are fetched on a daily basis. We found that VendA reports a disturbance, in case sales are lower in comparison to the former day, reflected by the statement that VendA *"always report a disturbance, but a real problem can't be found on-site"*. Moreover, we found that the disturbance is reported as one line and that the notification does not always reflect the problem. Additionally, there is no obvious difference in the length of disturbance from VendA and VendB, although VendA is equipped with telemetry.

At the wholesaler, we found that even though historical data about stock levels and purchases are existent these data are not available for the material planner at the wholesaler, indicating problems with information management capabilities. The employees at the wholesaler have to use multiple programs in the ERP system, resulting in self-made solutions such as Excel sheets. Furthermore, we found missing knowledge about supply chain management. Most knowledge was handed over from predecessors and was never questioned, reflected by the statement *"I don't know why. This is how it has been shown to me"*. The positive aspect is that a deeper analysis showed that the rate of lost turnover is below 1% of the firms' total turnover.

6 Discussion

Previous research has identified information sharing as enabler for supply chain performance (Straub et al., 2004). However, previous findings indicate seemingly contradictory attitudes towards information sharing. Therefore, we analyze the complementary role of contracts and bargaining power, in conjunction with trust and information management capabilities in determining the level and nature of information sharing within the context of a tobacco supply chain.

We found that contracts between suppliers and the wholesaler have been introduced only around ten years ago to replace meeting protocols. Contracts between suppliers and the wholesaler are used to specify information sharing. Accordingly, our findings support H1.1. Further, while the contract is used to formalize rewards from the suppliers towards the wholesaler, the stronger partner defines what kind of information needs to be shared. Therefore, the wholesaler shares transactional and operational information such as sell-in data from the retailer and vending machines with the suppliers, using various formats and technologies. In contrast, information between wholesaler and the retailers is shared without any contract, mostly reduced to a transactional level and orders are forwarded via E-Mail, Fax or Phone. Thus, again, implies that the stronger partner defines the information sharing behavior. In consequence, we found support for H1.3.

Despite that, from a technical perspective it is not described how information shall be shared. Therefore, the employees from the wholesaler need to have good information management capabilities, including knowledge about different formats and technologies. Our findings indicate differences in the existence of information management capabilities at the wholesaler, explaining the existence of informal solutions on an operational level; supporting our hypothesis H1.2. Further, we found that missing information management capabilities result in high costs for the retailer due to unscheduled deliveries, while only a low impact on the costs in the wholesaler-supplier relationship has been discovered.

In many industries bargaining power correlates with the size of firms, while in the analyzed tobacco supply chain bargaining power is on the suppliers and retailers side. The suppliers have a strong bargaining power position, due to brand loyalty and addiction of smokers. However, smokers and retail shops can get cigarette supply nearly everywhere. Accordingly, the wholesaler has the weakest bargaining power position in the supply chain with retailers, although his bargaining power position is better in the vending machine business. The retailer faces demand volatility from the consumer, especially due to the rich competition of retail shops. This is especially true for alternative products like cigars, cigarillos, and pouch.

We found that due to the weak bargaining power position of the wholesaler, the wholesaler either needs to offer a trade-off towards the retailers (such as an economic benefit) or is completely dependent on the willingness of the retailer in case the wholesaler wants to have further operational or strategic information such as forecasts; thereby supporting H2.3. However, as the wholesaler has the need to have an agile and flexible supply network (in order to compete on the market), the wholesaler cannot offer an incentive for the retailers. Therefore, the retailers do not see a reason for making supply chain specific investments, as they already get a satisfying delivery service. Due to the existence of informal solutions and the wholesalers´ dependency on the retailers, sharing of strategic information is expected to result in a monopolistic situation. As this does not reflect a *"win-win-situation"*, retailers avoid sharing of strategic information. In contrast, sharing of operational information (inventory) is not always seen as threat, therefore H2.1 can neither be neglected nor supported. Future research should investigate on a broader level, when and if firms perceive operational information sharing as good and strategic information sharing as threat.

However, this indicates that the wholesaler has to cover all risks such as investment in new electronic cash desks, decentralized inventories and less cash-flow, while the economic benefit needs to be shared, reflecting the strong bargaining power position of the retailer. The finding that firms do not use their bargaining power position to increase the level of information sharing, is in line with the statement from Supplier B that a trustworthy collaboration (vs. usage of coercive power) is of a higher value than information sharing (Maloni & Benton, 2000). This behavior improves the level of relational-trust within the supply chain relationship (Jeffrey H. Dyer & Nobeoka, 2000), therefore supporting H.2.2. In general, our findings indicate that in stable and price-transparent industries, a change in bargaining power is unlikely and there is no burden to share information. In addition, our results indicate that bargaining power can be used to punish partners in case of a high dependency related to cigarette sales. In contrast, rewards can be seen as bonus if it is an addition to existing revenues.

A high level of trust between retailers and the wholesaler was found as some retailers use the service from the wholesaler to electronically exchange transactional information, although no further information is shared. However, our research revealed that the willingness to share information with the wholesaler is given in case of personal connection and/or mutual performance gains, therefore supporting H3.1. Suppliers behave in a similar manner. In case of sales promotions, suppliers do not specify a promotion-related contract very precisely in the existence of a high level of trust. However, informal solutions avoid contractual penalties, therefore supporting H.1.2. Furthermore, all supply chain members stated, that the presence of trust is the most important aspect for business relationships, and that contracts reduce the level of trust, resulting in more cautious information sharing behavior; therefore supporting H3.3. In addition, our findings provide evidence for the declining importance of precisely specified contracts in case of trustworthy relationship, therefore supporting H3.2.

In addition, we analyzed the importance of different forms of trust for contracts and information sharing. Competence-trust represents the belief in the capabilities of the supply chain partner (Childe, 1998). Further, calculative trust effects information sharing and ensures win-win situations (Davis, 1993; Williamson, 1993a), while relational trust lowers the firms' fear regarding asymmetric information, reduces uncertainty, and decreases the risks of opportunistic behavior (Kramer, 1999). Therefore, relational-trust represents integrity, being honest and the avoidance of intentionally harm to the relationship (Newell & Swan, 2000). We found that within stable supply chains, relational trust is seen as the most important form of trust. Further, calculative and competence trust are named as the important aspects for a supply chain relationship. While relational trust allows firms to collaborate and exchange operational and/or strategic information, calculative trust is acknowledged as predictor to fair behavior. Competence trust relates to information management capabilities and the effort, which is needed to analyze and control for mistakes during information transmission. Therefore, competence trust positively affects the partners´ belief towards the information management capabilities such as data quality or cross-functional application integration, therefore, also supporting H.4.2.

Our results on information management capabilities indicate that retailers try to cover demand uncertainty by direct communication with the consumers. We found a high volatility of orders at the retailer without the electronic cash system. In contrast, the retailer with the electronic cash system has a stable demand with a low volatility, reflecting the importance of sophisticated cash systems. This indicates that the usage of electronic cash systems, which have their own supply chain logics such as to plan inventories and the possibility to electronically share the demand with the wholesaler, leads to more continuous and stable demands; therefore supporting H4.1. This results in higher supply chain performance at the retailer by ensuring the supply of cigarettes towards the consumer. Although the inventory information is shared by the retailer, it is not used at the wholesaler. This can be interpreted as missing information management capabilities at the wholesaler, while it can be recognized for the insignificance of information sharing in stable supply chains.

While we found support for the positive influence of information management capabilities on relevance and amount of shared data, we could not find support for the quality of shared information. However, as the quality of shared information is related to the amount of shared information, we can state that H4.1 has been supported. Further, we found evidence for good technical information management capabilities at the wholesaler (in terms of external information sharing), while weak internal data processing counter this aspect. Relevance, accuracy, general quality requirements, and flexibility of shared information seem to be focused and satisfied on the external demands from the suppliers, therefore, supporting H.4.1. The internal issues get very obvious as VendA transmits much data, which cannot be sorted according to its relevance by the employees of the wholesaler. We identified missing supply chain knowledge, training and technical integration of data towards the maintenance employee from the wholesaler as problem. We explain the internal problems by missing organizational structures, education of key persons and logistic training programs. Further, we found that the organizational structure, intrinsic motivation of employees, knowledge and resources affect information management capabilities of firms. Therefore, future research should consider managerial and leadership aspects as influence factors on information sharing. In addition, we felt, that the open and positive culture of the wholesaler stimulates and supports initiatives of employees to improve processes.

In addition to intended findings, we found that operational and strategic information sharing (such as inventory and capacity information) is not that important in case of stable supply chains, as the demand is transparent for all supply chain members; contrasting earlier findings (Klein & Rai, 2009; Straub et al., 2004). The demand for tobacco products from the consumers´ side is too stable, as strategic information like Point-of-Sales (POS) data would lead into better product availability. Accordingly, suppliers are able to implement a make-to-stock strategy and freeze their production plan for a long period. Hence POS data would be just useable for marketing actions from suppliers perspective and less to intercept short-term demand uncertainties (H. L. Lee, 2002), although this would be the major value of POS data.

However, in our case, sharing of forecast or inventory data would allow the wholesaler to improve process costs such as the avoidance of unscheduled transports, and a more accurate reaction towards retailer demands. Despite that, we found that this has an insignificant effect on the financial figures. Therefore, the relevance of information sharing always needs to be analyzed in the context of the industry. Further, this finding extends existing knowledge about efficient supply chains (H. L. Lee, 2002), as it reveals a vicious loop and explains why firms focus solely on their own and hesitate to mutually improve information sharing processes in efficient supply chains. Future research could analyze this effect more in relation to firm size and supply chain knowledge.

Our results conflate different theoretical perspectives. By inter-relating important aspects – which have been found as major influence factors on firms´ resistance towards mutual information sharing (Kampstra et al., 2006) –, we develop our research model to explain inter-relations and complementary effect on information sharing and supply chain collaboration.

Our findings suggest that trust in the expertise of a partner evolves over time. Furthermore, we found that the learning process out of problematic situations is the most significant one, also contributing to relational-trust. Moreover, the personal interaction plays a crucial role in developing this form of trust, as it is more connected to a person itself than to the company the person works for. Learning from daily information sharing processes allows supply chain members to influence the trust and bargaining power (Ghosh & Fedorowicz, 2008; Liu, Ray, & Whinston, 2010). Mechanisms such as experienced performance or handling of problems in a supply chain relationship play an important role for information sharing and affect future information sharing behavior (Patnayakuni, Rai, & Seth, 2006). In the wholesaler-vending machine relationship, we found that the usage of telemetry does not contribute to handle problems quicker, although information is shared, resulting in revenue losses. This can be partly explained by the relative newness of this technology and less experience with disturbance of VendA as they have been introduced between April and June 2011. Furthermore, firms experiencing a high accuracy of shared information or facing a good inter-personal communication relationship among supply chain members, realize a higher productivity and trust level (Ghosh & Fedorowicz, 2008; Hult et al., 2004). When talking about knowledge generation processes the learning through sharing of high valuable information will have a positive impact on supply chain knowledge (Jeffrey H. Dyer & Nobeoka, 2000; M. B. Myers & Mee-Shew, 2008). Therefore information management capabilities will likely be affected by learning (Simatupang, Wright, & Sridharan, 2002). Thus, further research should investigate the relation of learning towards trust and the impact on information management capabilities, especially from supply chain knowledge perspective.

7 Implications

This research advances theoretical understanding on supply chain exchange relationships by engaging TCE, RET and RBV as complementary perspectives. Therefore, we contribute to a better understanding of joint-influences on information sharing. Testing the proposed research model using qualitative data allows us to get a nuanced understanding regarding how different factors such as trust, bargaining power, contractual obligations (which are often broadly labeled as socio-political factors) interact with each other to determine information sharing. Our findings highlight the important of adopting a multiple theoretical perspective as the case data clearly shows the importance that supply chain members places on the development and maintenance of trust, while at the same time having contracts in place to outline mandatory supply chain specific actions.

Our study also provides several practical implications for managers and organization decision-makers managing paradoxical exchange relationships. For instance, the findings suggest that managers should create and shape a supply chain context that fosters collaboration between the firms while simultaneously guarding against the potential hazards of opportunistic behavior. This could be done by designing appropriate incentive system, creating platforms for resolving breaches, and using these in conjunction with formal contract definitions. Moreover, the various mechanisms that are used to govern the supply chain relationships need to be adjusted depending on factors such as the length of the relationship given that the very nature of the trust among supply chain members can evolve over time.

8 Limitations and Future Research

As with any research, some limitations surround our study. Our findings should be interpreted with caution, particularly when applied to other contexts. Our research model was tested using a single case-study of a tobacco industry supply chain. This gave us rich insights regarding how governance of exchange relationships evolve and are determined by different factors, and allowed us to control for extraneous variables such as organizational culture and industry characteristics. However, the generalizability of the model can be enhanced by testing it in more quantitative settings, such as using surveys. Finally, a more longitudinal case study would give better insights regarding how the balance between TCE, RBV, and RET changes of time, and identify factors that can moderate this shifting balance.

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Publication 7

An Ontology-based Platform to Collaboratively Manage Supply Chains [7]

Title	An Ontology-based Platform to Collaboratively Manage Supply Chains	
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Abstract

Setting up efficient supply chain networks is an important aspect of sourcing and supply chain management. We propose an ontology-based, knowledge-assisted platform to collaboratively create, adapt, and steer supply chain networks. Such platforms allow reuse of domain knowledge captured in previous supply chain projects and supports simulation of various network configurations. We developed a platform, which allows supply chain partners to share information, and generate mutually supply chain knowledge. In specific, we used Web 2.0 technologies to implement the platform, and used a modular structure to connect easily with other systems, or add own modules in case of specific requirements. Our research supports supply chain partners to exchange steer, plan, and control their supply chains, as well as sharing supply chain knowledge. In consequence, firms can use our platform to improve their supply chain efficiency. The main theoretical contribution is the platform, linking previous research towards a comprehensive concept for collaborative work within the field of supply chain management.

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Individual contribution from Tobias Engel: We wrote this paper in an iterative process with all co-authors. For example, I wrote the Introduction and Discussion chapter initially, while my co-authors wrote the middle section of the paper. Within the process, we commented on each other´s text, and modified the sentences; thereby developing the paper. Especially, the idea for the topic was provided by me.

1 Introduction

Supply Chain Management (SCM) allows firms to manage their upstream and downstream supply chains. This includes the physical flow of goods and information flows among supply chain partners from end users throughout suppliers of raw material (Cooper, Lambert, & Pagh, 1997; Rai, Patnayakuni, & Seth, 2006). Further, firms realize cost savings by analyzing supply chains and either improve the existing processes or implement new supply chains or supply chain strategies (Clark & McKenney, 1994).

Intra- and inter-firm collaboration is crucial for achieving supply chain performance (Horvath, 2001; Lee, So, & Tang, 2000). Collaboration not only allows firms to achieve mutual goals and performance gains by sharing information such as ideas, forecasts, inventory data, knowledge, but also risks and rewards (Cohen & Roussel, 2005; Nair, Narasimhan, & Bendoly, 2011). Within the field of SCM, inter-organizational information systems (IOIS) facilitate integration of unique processes across the supply chain and enable collaborative information sharing (Humphreys, Lai, & Sculli, 2001; Premkumar, 2000). Moreover, intra- and inter-firm collaboration results in greater end-customer satisfaction through improved supply chain visibility, reduced cycle times and increased flexibility to cope up with high demand uncertainties (Kumar & Banerjee, 2014). However, the level of collaboration among partners is low, and providing solutions for integrated processes to plan and steer supply chains is a key research area (Cognizant, 2014; Ooi, Chong, & Tan, 2011).

The advancements in web 2.0 technologies have transformed the way firms collaborate, share, and organize information. Improvements in information and communication technology allow firms to collaborate in effective and efficient ways (Chui, Miller, & Roberts, 2009). However, managing the supply chain network with all upstream and downstream supply chain flows from the point-of-origin to the point-of-consumption is a challenging task as domain specific knowledge is required (Fawcett, Magnan, & McCarter, 2008), and firms need a platform to collaborate (Ooi et al., 2011). Therefore, supply chain practitioners are required to have domain knowledge to plan, design, and manage supply chain structures and their configuration.

Despite that, shorter product-life cycles, increasing competitive pressure and market globalization force supply chain practitioners to shorten the implementation cycles of new supply chains, and to optimize the existing supply chains in more efficient ways. Firms need to ensure a quick, agile, and flexible response time to changing customer needs (Lee, 2002; Thomas & Griffin, 1996). Further, supply chain practitioners need to collaborate across firms´ boundaries complicating implementation and improvement processes. Hence, the collaboration efforts and the dynamic environment create the need for assistance, and the creation of synergies to ensure supply chain performance.

Therefore, it is necessary that existing IOIS evolve and adapt these advancements to support collaborative planning and steering processes. These advancements allow an incorporation of new information and communication technologies to support firms with new collaborative solutions. Further, these solutions will allow firms to handle complex supply chains in a robust, reliable and flexible way using a validated knowledge base. In consequence, we propose a platform – iSupply – to support supply chain practitioners to collaboratively plan, design and manage supply chains within a short response time.

The requirements and advancements are realized within the platform by a feature to collaborate, drawing domain-specific knowledge by comparing existing data with planned data, and providing practitioners with supply chain specific constraints and KPIs. More specifically, to resolve the presented issues, the iSupply platform comprises of four main components, which can be used in a collaborative mode: (a) knowledge base, (b) simulation engine, (c) calculation model, and (d) visual editor. The ontology forms the core of the knowledge base, the simulation engine allows "what-if" analysis, the calculation model provides business logic, and the diagram editor supports the perception of changes and requirements for the supply chain experts and practitioners. Further, the knowledge base can be classified into (a) supply chain, (b) context, and (c) logistics ontology; the simulation engine gives insights for setting supply chain network constraints; and the calculation model presents total supply chain costs using domain specific constraints.

2 Related Work

Domain specific knowledge both tacit and explicit knowledge is often organized within knowledge management systems (Alavi & Leidner, 2001). Knowledge management in itself is a systematic approach to capture, structure, disseminate, manage, and reason about the knowledge throughout a firm (Douligeris & Tilipakis, 2006). Previous research shows a growing interest in applying knowledge based approaches in the field of SCM (Marra, Ho, & Edwards, 2012; Samuel, Goury, Gunasekaran, & Spalanzani, 2011). These approaches integrate knowledge management at the granularity level of technical information, order information, material, and financial flows (Pedroso & Nakano, 2009). This level of granularity contributes towards achieving strategic goals such as agility, adaptability, and the alignment through efficient knowledge flows and knowledge sharing process (Whitten, Green, & Zelbst, 2012). In the context of SCM, knowledge flows and knowledge sharing processes represent domain-specific knowledge. However, domain-specific knowledge is not continuously explicit. Therefore, we propose a knowledge-based approach to capture, to structure, and to reuse knowledge of supply chain projects. This includes, but is not limited to, requirements to design, plan, simulate, and analyze variants of supply chains for identifying an optimal supply chain network.

Marra et al. (2012) study the role of knowledge management in SCM by reviewing 58 journal articles in which knowledge management approaches are proposed in supply chain context. Their findings highlight (a) Knowledge management and its fit for SCM, (b) a growing interest for applying knowledge management in supply chains projects and (c) the missing discussion on knowledge accumulation and sharing at the granularity of projects with different scenarios of supply chain networks. Further, Samuel et al. (2011) view knowledge management as an enabler for SCM and propose a conceptual framework for knowledge management in supply chains. However, the concepts in the framework are at an abstract level that focuses on capturing tacit and explicit knowledge among supply chain partners. To achieve supply chain competitiveness, Samuel et al. (2011) discuss the need to consider the concepts and the semantic relationships of the supply chain networks in the conceptual models and ontologies.

The benefits of using ontologies such as interoperability among disparate information systems, and reasoning about the knowledge through semantic inter-relationships of concepts are discussed in Douligeris and Tilipakis (2006). They provide only a minimalist view on their SCM ontology along with the use-cases. Despite that, even with such a minimalistic model, the advantages of semantic web technologies have been proven, and can be seen as first steps towards realizing information systems based on ontologies for SCM. Douligeris and Tilipakis (2006) however do not demonstrate in their proposed prototype how to handle knowledge interoperability among disparate information systems.

Knowledge interoperability is hindered by the use of inconsistent terms and semantics in supply chain domain (Ye, Yang, Jiang, & Tong, 2008). Ye et al. (2008) propose the use of ontologies for semantic integration. Further, their ontology is structured into different supply chain categories such as structure, activity, resource, and management. This structure allows capturing domain knowledge of supply chains through concepts and their relationships. The challenge of interoperability and knowledge sharing in supply chain context is further addressed by Huang and Lin (2010). Huang and Lin demonstrate how semantic web technologies such as Resource Description Format (RDF) and RDF schema capture the meta-knowledge and address the problem of knowledge interoperability. Hung and Lin propose a platform, which includes an annotation process that extracts concepts and relationships from heterogeneous knowledge sources.

Fayez, Rabelo, and Mollaghasemi (2005) propose a supply chain ontology by extending concepts from the Supply Chain Operations Reference (SCOR) model. The concepts in supply chain ontology are categorized into different perspectives such as supply chain, enterprise, enterprises' elements, and interaction perspective. The supply chain ontology captures distributed knowledge to build simulation models for decision making in SCM. Fayez et al. (2005) identify three supply chain simulation modeling problems namely: Dynamics, Complexity, and Heterogeneity. To cover the dynamic aspect, firms have to synchronize their knowledge sources and real-time data should be made available to run simulations and to perform analysis. Further, complexity results in long cycle time of supply chain projects and the solutions offered by the end of the projects might be outdated or the context of the problem could have changed. Finally, heterogeneity of information systems creates a need to harmonize structures, formats, and availability of required data. Further, Fayez et al. (2005) discuss how the issue of interoperability can be handled with a supply chain simulation ontology, but miss to address supply chain dynamics and supply chain complexity.

Franzese et al. (2006) and de Ruiter, Sluijs, and Stoutjesdijk (2000) propose a template based approach for reusing knowledge and past experiences in supply chain projects. Their case studies show a significant reduction of time and effort in supply chain projects. However, the lack of an extensible conceptual model in these template based approaches makes the applicability very restricted to specific problem domains, and generalization of these approaches becomes difficult.

The importance of domain specific knowledge captured in ontologies for efficient SCM, and the role of web technologies in enabling interoperability and knowledge sharing has been validated in previous research. However, we found a missing integrated approach that addresses all the three aspects of supply chain dynamics, complexity, and heterogeneity. In consequence, we propose a platform to enable the activities including knowledge sharing and decision making in an integrated collaborative environment to plan and steer supply chain processes.

3 Overview

In this section, we first briefly discuss the design science approach used to design and develop the iSupply platform, followed by an overview of the components in the iSupply platform. Design science is a technology oriented research framework (March & Smith, 1995). Hevner (2007) propose three closely related activities in design science research, namely:

(a) Relevance Cycle: is an iterative process, which identifies opportunities in an application context and defines acceptance criteria for evaluation of the research artifacts. This cycle also involves testing of research artifacts and getting feedback from end-users.

(b) Rigor Cycle: ensures originality in research projects by comparing the planned research contribution against the scientific knowledge base, and allows researchers to contribute their research insights and artifacts to the scientific knowledge base.

(c) Design Cycle: is an iterative process for implementing and evaluating the design artifacts and processes based on the inputs from the relevance and rigor cycle.

The design of iSupply platform architecture and the development of the prototype loosely follow Hevner's three cycle view of design science research. Introduction and related work section of this paper establishes the relevance of our research in SCM domain and captures the opportunities and requirements for the architectural design of the platform. Corresponding to the rigor cycle, we ground our design artifacts on the well-established, successfully implemented and tested technological concepts proposed by Bhat et al. (2013), Fayez et al. (2005), Ghaisas (2009), and Ye et al. (2008); this allows us to contribute to the supply chain research community. Further, the internal design cycle involves the implementation of the iSupply platform.

3.1 iSupply Platform Overview

iSupply is a collaborative platform developed using web 2.0 technologies. The platform allows supply chain practitioners to collaboratively design supply chains in a user-friendly, HTML5-based diagram editor. Within the editor, practitioners have the possibility to visualize the supply chains. Further, the integrated wiki, discussion forum and polls allow practitioners to share knowledge and communicate while working on supply chain projects. To enable knowledge reuse and collaboration in supply chain projects, iSupply platform incorporates different components such as knowledge base, simulation and collaboration engine and calculation models as depicted in Figure 1. We start by describing the knowledge base and the ontologies, followed by the iSupply platform architecture and its components.

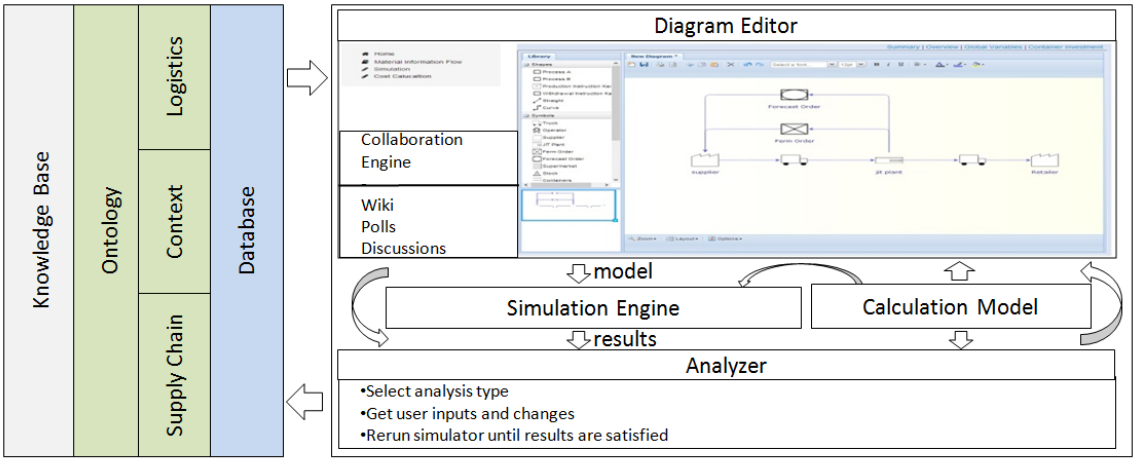


Figure 1 – iSupply Platform

3.2 iSupply Knowledge base

The knowledge base serves as an information repository and the integrated components can access this knowledge base through an integration bus. The knowledge base comprises of the iSupply ontology, which allows capturing, structuring, and selectively reusing domain knowledge. iSupply Ontology is categorized into three ontologies namely *supply chain*, *context* and *logistics* ontology. The supply chain and logistics ontologies are derived from the existing SCM models proposed by Fayez et al. (2005), Lian, Park, and Kwon (2007) and Ye et al. (2008), and the context ontology is derived from (Ghaisas, 2009) which defines the scope and boundaries of supply chain projects. An extract of the iSupply ontology is represented in Figure 2.

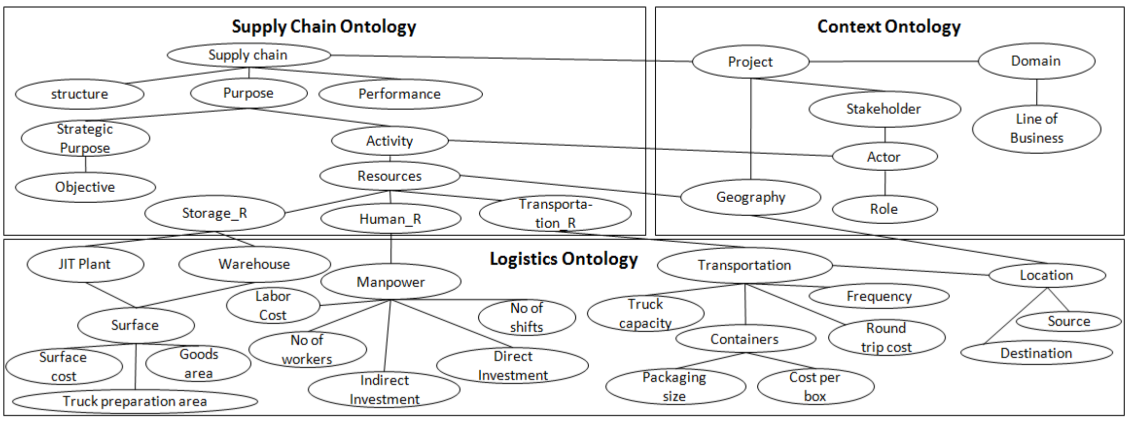


Figure 2 – Extract of iSupply Ontology

The **supply chain** ontology captures concepts such as purpose, activity, resource, structure, and relationship between the concepts. For example, to satisfy specific business goals and purpose, and to meet stakeholders' requirements, supply chain projects involve performing activities such as manufacturing, packaging, maintenance, and distribution over a period of time. These activities are managed by actors with designated roles in an organization. Actors manage the allocation of resources such as transportation, storage, and human resources to the activities and ensure optimal resource usage and timely completion of the activities. Further, the supplier-buyer relationships between stakeholders are captured in the supply chain structure. A detailed description of these concepts is documented in (Ye et al., 2008).

The **logistics** ontology further extends the concepts in the supply chain ontology through relationships with concepts such as *storage*, *transportation,* and *human resource*. It also consists of concepts including *transportation*, *truck*, *truck capacity*, *frequency, source* and *destination location*, *round trip cost*, *manpower*, *shifts*, *labor cost*, *storage surface* and *surface cost* along with associations between concepts in logistics ontology as well as supply chain and context ontology. For instance, let us consider *distribution* of *containers* from a *Just-in-Time (JIT) plant* to different *warehouses* using *trucks* as *transportation units*. The trucks transport *containers* from the *source* (JIT plant) to the *destination* location (warehouse). The *packaging size* of the container and the *capacity* of the truck determine the *number of containers* transported in one round-trip. Further, the number of containers transported and the *transport cost for one container* from the source to the destination location determines the total *round-trip cost*. The activity *distribution of containers* requires *manpower* for *loading* and *unloading* trucks, *moving*, *sorting* and *piling* arrived containers and so on. The *number of workers* involved in these activities, their *number of shifts* per day and the *unit manpower cost* for each corresponding activity determines the total *labor cost*. Apart from the transportation and human resources, the activity *distribution of containers* also requires *storage resources*. In this scenario, the storage resources are the *JIT plant* and the *warehouses*. A *JIT plant* has allocated *storage area* for performing further actions such as *storing containers* or a *quality check*. In consequence, all activities (costs) are summed up, and determine the *total cost of the supply chain*.

The **context** ontology captures concepts specific to the project and its environment such as *project*, *domain*, *stakeholder* and *geography*. It also captures association between concepts such as "*project* belongs to a specific *domain*", "*project* is associated with multiple *stakeholders*" and "*project* has a corresponding *geography*". Supply chain practitioners can specify rules and constraints on the concepts in the ontology. For instance, consider a supply chain project in Germany (*geography*), the German law requires 24 working days (wd) as vacation (~11% if we use 220 wd) for direct labor. As an addition, it can be assumed that employees are ill for five wd (equals ~2% in case of 220 wd). Supply chain practitioners can capture such constraints as default values for *vacation* and *illness* attributes of the concept *direct labor* within the logistics ontology. While supply chain practitioners carry out projects with similar context and environment, these rules and constraints in the iSupply ontology allow deriving and presenting recommendations such as the minimum number of days to be considered for vacation and illness of the (direct) labor. This exemplary constraint (data) is further used by the calculation models of the iSupply platform to compute the total cost for (direct) labor in a supply chain.

Further, the data which has been captured throughout the process can be transformed into structured knowledge, and acts as a coherent source of information for the simulation engine and the calculation model within the iSupply Platform. This also allows using the diagram editor and collaboratively working on the supply chain.

3.3 iSupply platform architecture

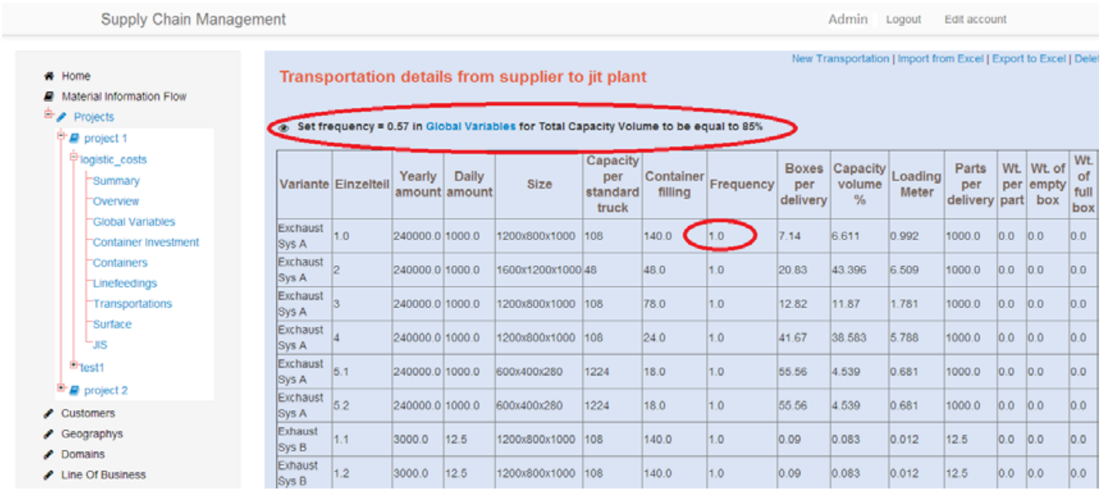
As in our iSupply platform all components – the diagram editor, the simulation engine, the calculation model and the collaboration engine – are inter-connected, it is necessary to gain a basic understanding of the iSupply architecture. The architecture is adapted from Bhat et al. (2013) enabling all components of the iSupply platform to interact with each other and access the same knowledge base through an integration bus. This inter-connectedness, and the modular setup of the iSupply platform allow users to add new components to the platform by using component adapters. These adapters allow integration of customized software components to the platform. All components are independent and can be (re-)configured or replaced by other components simply by being plugged into the iSupply platform. Further, component adapters provide extensibility allowing users to integrate custom simulation engines, calculation models and collaboration engines.

The **diagram editor** provides supply chain practitioners with the possibility to model the supply chain networks with symbols, derived and extended based on the definition from Erlach (2007). The editor allows to model material and information flows. The used symbols represent objects such as plants, trucks, operators, containers, or forecast order. The HTML 5 based diagram editor allows supply chain practitioners to add these symbols through an implemented drag and drop feature, and to capture specific attributes for each of the constructs.

Simulations form an integral part of the iSupply platform. Once the supply chain practitioners model the supply chain network and capture necessary details and data about the supply chain in the diagram editor, this model is used as input for the simulation engine. Simulations are run to identify bottlenecks in the supply chain network. For instance, simulations provide insights for supply chain network constraints such as the number and frequency of transportation units from the Just-in-Time (Sequencing) plant to the warehouse. Detailed reports of the simulation are presented to the supply chain practitioners, and based on the analysis they can update and re-run the simulation for the chosen supply chain model. For example, Figure 3 presents the report on transportation details from a supplier to a just-in-time plant. The iSupply platform suggests reducing the transport frequency and increasing its transportation units from one truck per day to about two trucks per day to maintain an optimal storage capacity (85%) of the truck. In consequence, the simulation engine allows firms to gain an understanding to optimize specific processes on their own, and see the influence on the complete supply chain.

The iSupply platform consists of an integrated **calculation model**, which is responsible for the calculation of all supply chain costs including costs such as transportation, labor, or indirect costs in plants. This allows supply chain practitioners to calculate for each supply chain specific costs, respecting and include the context of the project boundaries and specific rules. Based on these rules the platform calculates the total estimated costs of the supply chain network and presents a detailed report to the supply chain practitioners. The report captures a summary of the total costs per lifetime and total costs per piece.

The **collaboration engine** comprises of wiki, discussion forum, and polls. The wiki serves as a documentation platform allowing users to capture and share information such as workflow of supply chain activities including outsourcing, manufacturing, warehousing, and distribution. Moreover, users can also tag the content with keywords allowing other users to easily search and retrieve specific content. For example, a user can document the German labor law and tag the information with the keyword “law”. At any point when the keyword “law” is searched, all the documents tagged with this keyword including the German labor law are retrieved. Users can also create groups and discuss specific topics or post questions that could be answered by experts in the discussion forum. The discussion forum not only connects users from different supply chain partners but also provides a quick means to address problems by considering different perspectives from different partners. Further, polls provide an easy way to conduct surveys targeting specific groups or even polls across all the supply chain partners.



Variante	Einzelteil	Yearly amount	Daily amount	Size	Capacity per standard truck	Container filling	Frequency	Boxes per delivery	Capacity volume %	Loading Meter	Parts per delivery	Wt. per part	Wt. of empty box	Wt. of full box
Exchaust Sys A	1.0	240000.0	1000.0	1200x800x1000	108	140.0	1.0	7.14	6.611	0.992	1000.0	0.0	0.0	0.0
Exchaust Sys A	2	240000.0	1000.0	1600x1200x1000	48	48.0	1.0	20.83	43.396	6.509	1000.0	0.0	0.0	0.0
Exchaust Sys A	3	240000.0	1000.0	1200x800x1000	108	78.0	1.0	12.82	11.87	1.781	1000.0	0.0	0.0	0.0
Exchaust Sys A	4	240000.0	1000.0	1200x800x1000	108	24.0	1.0	41.67	38.583	5.788	1000.0	0.0	0.0	0.0
Exchaust Sys A	5.1	240000.0	1000.0	600x400x280	1224	18.0	1.0	55.56	4.539	0.681	1000.0	0.0	0.0	0.0
Exchaust Sys A	5.2	240000.0	1000.0	600x400x280	1224	18.0	1.0	55.56	4.539	0.681	1000.0	0.0	0.0	0.0
Exhaust Sys B	1.1	3000.0	12.5	1200x800x1000	108	140.0	1.0	0.09	0.083	0.012	12.5	0.0	0.0	0.0
Exhaust Sys B	1.2	3000.0	12.5	1200x800x1000	108	140.0	1.0	0.09	0.083	0.012	12.5	0.0	0.0	0.0

Figure 3 – Transportation details from a supplier to a just-in-time plant

In order to collaborate from different geographical locations, the iSupply platform has been developed as a web application, which allows users to simultaneously log-in to the system. In consequence, users can make changes to the supply chain models while mutually view changes and analyze the results in an integrated collaborative environment. As the web application is hosted on an application server, users can access the system using a web browser. No further client-side software installation is required.

4 Discussion and Implications

Recent benchmark studies on supply chains still reflect the need for improved collaborative and integrated supply chain planning and execution systems (Cognizant, 2014; Simonson, 2010). Since firms use a variety of planning components such as demand planning, supply planning, production scheduling, and supply chain network planning, integrating these components are key challenges; especially from an inter-firm perspective.

As discussed in the related work section, semantic web technologies are extensively being used to represent knowledge explicitly to enable interoperability among heterogeneous software components (Huang & Lin, 2010; Ye et al., 2008). However, the supply chain ontologies proposed by Huang and Lin (2010) and Ye et al. (2008) do not consider concepts at the granularity level of supply chain projects along with its contextual information. Our research complements the above contributions and extends the existing supply chain ontologies with project specific concepts to enable reuse of knowledge in supply chain projects.

Apart from collaboration and interoperability issues, there also exists a need for shorter cycle times to cope-up with the demanding supply chain markets. Researchers have addressed this challenge through the use of reusable templates (de Ruiter et al., 2000; Franzese et al., 2006). However, these approaches do not discuss how the knowledge captured through the templates can be structured in the knowledge base, and do not address the issues of supply chain dynamics and heterogeneity. We also make use of templates, in the form of reusable projects comprising of supply chain configurations, its underlying models, simulations, and results captured and structured in ontologies. The ontology and the knowledge base are incorporated into a collaborative platform for assisting supply chain practitioners to plan and steer processes in supply chain projects by reusing supply chain domain knowledge.

5 Limitations and future research

The design and development of the collaborative and integrated iSupply platform should be interpreted in the context of its limitations. In our approach, we do not focus on the annotation of heterogeneous information from repositories and mapping of heterogeneous ontologies. However, we build on the knowledge base to enable activities such as simulation and analysis in supply chain projects. It is critical that the knowledge base, which acts as a coherent source of information to different components of the platform is consistent and reliable. Further, we did not test the scalability of our platform in real life industry projects; while the platform has been developed in cooperation with two supply chain experts. Thus, further evaluation needs to be done. Evaluation of the platform within the industry will help to identify shortcomings of our developed prototype, and provide new requirements and directions to improve the platform.

6 Conclusion

The main contributions of this paper are three-fold: We propose the architectural design of an ontology-based, knowledge-assisted SCM platform – iSupply – and discuss how practitioners can reuse supply chain knowledge to handle dynamic, heterogenic, and complex supply chain environments. Secondly, the platform assists and guides practitioners in reusing domain knowledge to reduce the time and effort involved in supply chain projects. Thirdly, the platform architecture is extensible and configurable providing supply chain practitioners the flexibility to enhance the system by adding/replacing components.

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Publication 8

CostRFID: DESIGN AND EVALUATION OF A COST ESTIMATION METHOD AND TOOL FOR RFID INTEGRATION PROJECTS

Title	CostRFID: Design and evaluation of a cost estimation method and tool for RFID integration projects	
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Abstract

Although many firms have initiated RFID projects, they often face significant difficulties in integrating RFID-systems into their existing IT-landscape. One such difficulty is the upfront estimation of the cost of the RFID integration project. Our research addresses this issue by using a design science approach to provide a cost calculation approach for RFID integration projects. Drawing from literature in the fields of information systems and RFID, software engineering and supply chain management, we develop the cost calculation method which is then implemented in a prototype. The prototype is developed and evaluated in an iterative fashion using focus groups, RFID-experts, and the cognitive walkthrough method. We contribute to theory by proposing a new cost calculation method to estimate the costs of RFID integration projects. Practical implications include a more accurate estimation of the cost of integrating RFID system into the existing IT-landscape, and therefore, a risk reduction for RFID projects.

Individual contribution from Tobias Engel: My contribution to Publication 8 is the development of the prototype, and its evaluation. Furthermore, I wrote all chapters in a first German version, revised the first English version, and addressed comments from my co-authors in the second English version. The final (third) version was proofread and submitted by my co-authors.

1 Introduction

RFID offers several advantages over traditional auto-ID technologies such as higher object identification speed, higher storage capacity, and allows firms to improve processes in the fields of manufacturing, distribution, transportation and retail (Roh, Kunnathur, & Tarafdar, 2009; Roussos, 2006; Rutner, Waller, & Mentzer, 2004; Thiesse, 2005; Want, 2006; Weinstein, 2005). Furthermore, RFID-technology allows for improved data quality and information availability, and therefore enhances intra-organizational operations (Fosso Wamba & Chatfield, 2009), and increases information visibility among supply chain partners (Delen, Hardgrave, & Sharda, 2007; L. Lee, Fiedler, & Smith, 2008). Therefore, many firms are considering investments into RFID technology or have already invested in the technology (L. Lee et al., 2008). One major aspect of RFID implementation projects is the integration of RFID systems into the existing information technology (IT) systems of the organization so that it can enhance business processes (Strueker & Gille, 2008), and allow firms to optimize information and material flow (Fosso Wamba & Chatfield, 2009). However, the integration of RFID-systems into the existing IT-systems of firms is a complex process that can result in several implementation problems. In particular, the upfront estimation of RFID system integration costs can be difficult due to the complexity and uniqueness of RFID projects, leading to a wrong estimation of the cost and effort required for executing the integration project (Angeles, 2005).

Having relatively accurate project cost estimation is an important factor in the decision making process of firms during the early stages of project planning, and is a well-known issue in the field of information systems (IS) (Boehm, Abts, & Chulani, 2000). Realistic expectations and the definition of clear objectives are necessary for IT projects in general (Hartman & Ashrafi, 2002; Reel, 1999; Smithson & Hirschheim, 1998), and for RFID software projects in particular (Dickson, 2007). Since RFID projects have to integrate hardware and software into the existing IT infrastructure, traditional software cost estimation methods are not suitable for the upfront cost estimation of RFID projects. While RFID system integration has been identified as a major cost factor in RFID-projects, the lack of an appropriate cost estimation method still represents a major drawback for the widespread adoption of the technology (Asif & Mandviwalla, 2005). Being able to calculate the cost at the project outset in advance can help organizational decision-makers to decide if and when to carry out the implementation project, and also decide on the various applications that they can design around the technology by integrating it with other existing IT systems within the organization. Therefore, this research aims to develop a cost estimation method for RFID projects specifically focusing on the integration of RFID into existing IT systems within the organization.

Considering the inter-disciplinary aspects of RFID technology, we draw from the domains of information systems, auto-identification technology, and software engineering to develop a cost estimation method for RFID integration projects. The cost estimation method developed is based on established cost estimation methods that exist for software development projects, and in particular draws upon the COCOTS model that incorporates commercial-of-the-shelf (COTS) components in the cost estimation of software projects (Abts, Boehm, & Clark, 2000). Since a typical RFID system infrastructure comprises off-the-shelf components that are configurable (such as tags, readers, middleware) (Maier, 2005; Thiesse, 2005), the COCOTS model is particularly applicable in the context of RFID projects. We further adapt the COCOTS model to take RFID-specific requirements into account, and develop a new cost estimation method for RFID integration projects. The developed cost estimation method is used as a basis for designing the RFID cost calculator tool. The iterative development and evaluation of the RFID Cost Calculator is congruent with the design science paradigm and the three cycle view on information system design as proposed by Hevner (2007). The cost estimation method and the cost calculation tool can support managers and practitioners in calculating RFID-system integration costs more accurately, and can therefore help in determining the economic viability of RFID integration projects. For instance, the tool offers the possibility of simulating several RFID application scenarios and then estimating their costs in order to gain a better understanding of emerging costs in RFID integration projects beforehand, or choosing among various RFID use cases that should be implemented first. Further, the tool supports the controlling of RFID-projects.

The rest of this book chapter is structured as follows. In the next section, we provide an overview on RFID technology and the relevant RFID-infrastructure. Furthermore, existing cost estimation methods are introduced and their applicability in the context of RFID system integration is described. Concluding the theoretical background section, the design science paradigm, which serves as the theoretical framework during the design exercise, is presented. In the design section, the problem relevance using a simple use case scenario is demonstrated followed by a detailed description of the design and evaluation of the RFID cost calculator tool. In the subsequent sections, we provide a discussion of our findings, research limitations and implications and a conclusion.

2 Background and related work

In this section, we provide an overview of RFID technology and describe the basic IT infrastructure configurations, which are necessary for RFID implementation and integration. Furthermore, we analyze software cost estimation methods and evaluate their applicability to RFID projects. Finally, we introduce the design science paradigm, which serves as a basis for our methodological approach.

2.1 Basics of RFID systems

The components of a typical RFID system can be categorized into three different layers according to their level of abstraction from the underlying physical processes. An illustrative architecture of IT components that are used in RFID projects, adapted from (Dittmann & Thiesse, 2005), is depicted in Figure 1.

The infrastructure layer includes RFID transponders and RFID readers, referred to as components. These components are used to identify physical objects and to acquire data via electromagnetic waves. The RFID transponder, also referred to as RFID tag, is a combination of a transmitter and a responder (Roussos & Kostakos, 2009), and has to be attached to every item that needs to be identified. The RFID reader acquires the data using the built-in antennae and radio waves and forwards it to the integration layer.

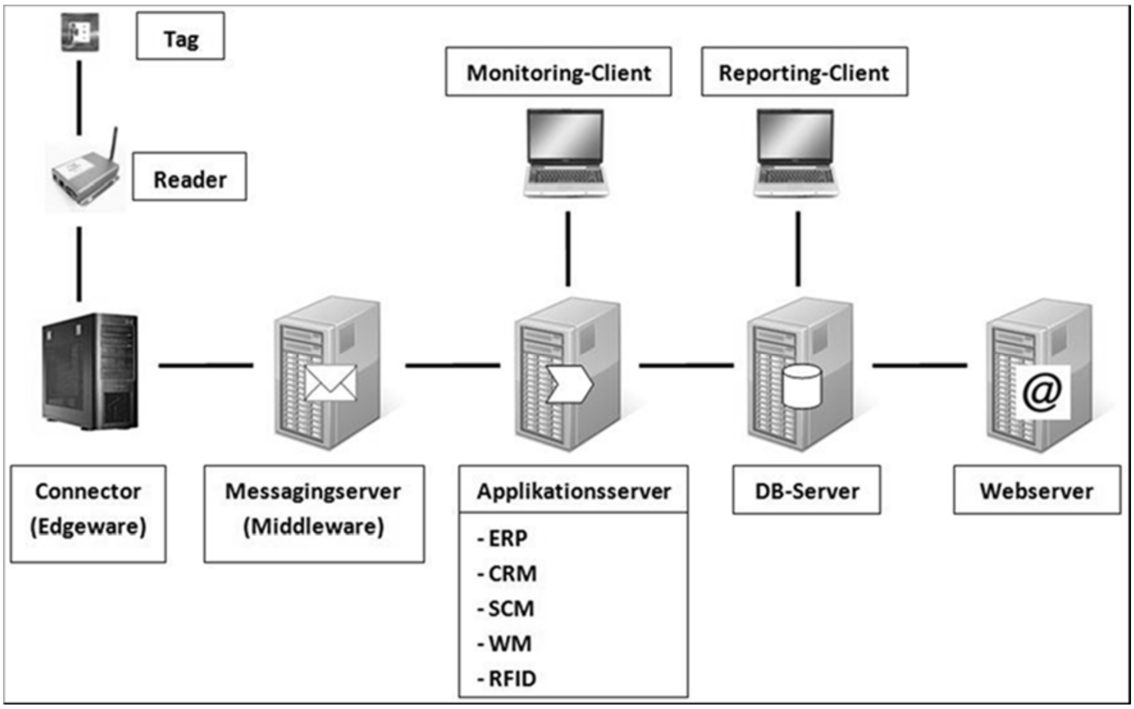

Figure 1 – RFID components, adapted from Dittmann and Thiesse (2005)

The integration layer contains middleware and edgeware and integrates the RFID reading devices into existing IT-systems allowing data exchange between the components (Thiesse & Gross, 2006). Edgeware components are part of the middleware and preprocess data through filtering, correction or format transformation. Edgeware is also used to coordinate the communication between the RFID hardware and middleware (Hansen & Gillert, 2006).

There are two possible strategies for the integration of RFID components into existing IT-systems. The first possibility is to implement an interface directly into the IT-system or the RFID-system. This strategy faces the problem of economic feasibility especially with regards to big sized IT-backend systems and their high level of complexity. The second possibility is to use enterprise application integration (EAI) which offers a range of opportunities. The EAI component is located between the RFID system and the corporate IT-backend system and enables data exchange between the systems. In one direction, the EAI component forwards information to the backend system through standardized protocols such as XML messages. In the other direction, the EAI component receives commands from the backend system and delivers them to the RFID system (Fleisch & Mattern, 2005). It is possible to include any desired system into this infrastructure by the use of interfaces or data mapping (Krcmar, 2010).

The application layer describes the processing of RFID data using IT-backend systems. Information can be shared with internal systems or inter-organizational networks (Thiesse & Gross, 2006). The application server enables the separation of processing logic from data storage and presentation. In RFID systems, the application server hosts every component used to gather, analyze, and store RFID data. Additionally, the application server can host IT infrastructure components such as enterprise resource planning, customer resource management, supply chain management, or warehouse management systems.

RFID information is stored on the database server, which can only be accessed in read mode by complementary systems. Moreover, monitoring clients can be used to trace the RFID system in real time, while the reporting client files reports and analyses in order to ensure the efficiency of business processes. Security is ensured by the combined usage of a firewall, a webserver and web-client ensuring data encryption and protection against internal, external and internet attacks on the system (Krcmar, 2010).

All components and systems discussed in this section were considered in the process of developing the RFID cost calculation method.

2.2 Past research on software cost estimation

The purpose of a cost estimation method is to indicate cost sources and factors influencing costs in order to enhance accuracy in the evaluation of upcoming tasks and efforts (Dowie, 2009; Schuster, 2012; Vollmann, 1990). Influencing factors can be categorized as product specific and project specific. Product specific factors include the quantity and complexity of tasks as well as the expected quality of results. Project specific factors include basic parameters of the project such as estimated length, level of know-how, programming and modeling languages, development environment and many more (Sneed, 2005). Due to the variety of parameters, each estimation method is based on an individual set of factors (Wieczorrek & Mertens, 2011). In the course of our literature review, we analyzed cost estimation methods from the domains of software engineering and information systems including function-point analysis, data-point analysis and object-point analysis (Bundschuh & Fabry, 2000; Sneed, 2005). We found that the majority of the reviewed cost estimation methods were applicable to the development of new code, whereas RFID projects are usually realized through the use of commercial-off-the-shelf (COTS) components. Commonly expected benefits of COTS components include reduced development time, lower costs and higher product quality (Abts et al., 2000). Therefore, COCOTS - a cost estimation method based on COTS components, and derived as an extension of COCOMO I and COCOMO II can be considered as relevant to RFID-system integration projects, due to its focus on system integration and its applicability for reusable components (Abts et al., 2000).

COCOMO is an abbreviation for the Constructive Cost Model, which was developed in 1981. Cost estimation using COCOMO I is based on code instructions in the form of lines of code (LOC). With the help of predefined formulas, COCOMO allows for calculation of project costs regarding labor effort and system complexity. However, since neither product quality nor project specific parameters are taken into account as influencing factors, the use of this model is not plausible from a present-day perspective.

The COCOMO II model extends COCOMO I, and uses a three-step approach for cost estimation. In the first step, the early prototyping phase, the effort for developing a reusable prototype is estimated. The aim of this estimation is to give a first impression of the overall project effort. The second step, the early design phase, takes place after the definition of system requirements and following the design of an early draft. The draft is then translated into lines of code (LOC) and used for the cost estimation. In the third step, the post-architecture level, the effort estimation takes place in hindsight of the entire development process. This step uses LOC which are derived from the final architecture and offers more detailed insights into support and maintenance efforts (Boehm, Madachy, & Steece, 2000; Gencel, Heldal, & Lind, 2009; Zhang, 2009). While COCOMO II takes a more holistic view of the project in order to estimate development costs, it is still primarily based on lines of code and therefore cannot be used in the context of RFID integration projects, where there is little effort involved in code development (Boehm, Madachy, et al., 2000).

The COCOTS estimation method extends COCOMO II by incorporating commercial-of-the-shelf (COTS) components in the calculation of costs. COTS components offer instant availability for use with standards compliance, therefore fulfilling modern software development requirements like the implementation of various standards, protocols, toolkits, and technologies (Vigder & Dean, 1997). The COCOTS model identifies four phases, which depict the software development process. First, initial, and detailed assessments have to be conducted to arrive at a selection of necessary components. The second step, tailoring, addresses the integration of the selected components into the existing system. The glue code development and associated test cycles complement the system with necessary functionalities and further ensure the interoperability of system components. In the final phase, system volatility, code changes, and updates by the manufacturer that may result in training effort are evaluated (Abts et al., 2000; Naunchan & Sutivong, 2007; Yang, Boehm, & Wu, 2006).

Although, none of the analyzed cost estimation methods fully satisfy the necessary criteria required for RFID system integration projects, they do provide partial solutions. RFID projects are inter-disciplinary in nature and their configuration is usually very specific to the organization. Therefore, while RFID projects make use of COTS components, there is also significant effort involved in fine tuning the project to handle the specific requirements of the organization. Therefore, based on our literature review, we believe that a cost estimation method for RFID projects could draw from COCOMO I & II and COCOTS as relevant bases for the calculation of information system integration costs for RFID-projects.

2.3 Design science paradigm

We chose the design science paradigm (March & Smith, 1995) as the research methodology guiding the systematic development of the RFID cost calculator tool (Hevner, 2007). Design science is technology-orientated research that includes the creation of artifacts and its assessment against criteria of value or utility (March & Smith, 1995). Constructs, models, methods or instantiations are outputs of design science and can be referred to as design artifacts (March & Smith, 1995). More specifically, drawing on three cycle view of information systems design that comprises relevance cycle, design cycle and rigor cycle (see Figure 2) as proposed by Hevner (2007), we used an iterative process to design, develop and evaluate the RFID cost calculator.

In our research, the design artifact is manifested in the form of the RFID cost calculator prototype application. Knowledge base of software engineering and existing cost calculation methods substantiate the design of the artifact (Hevner, March, Park, & Ram, 2004). Building and evaluating the artifact are the two major activities in any design science research. According to Hevner (2007) the design cycle process is an iterative loop, allowing the generation, evaluation and optimization of alternatives until a satisfactory status of the artifact is accomplished. Functionality, completeness, consistency, accuracy, performance, reliability and usability are the main evaluation criteria for design artifacts (Peffers et al., 2006). The necessary requirements for the design artifact have to be identified in the specific context of each application to ensure a stable basis for building, optimizing and evaluating the artifact. Additionally, the results of the artifact need to be iteratively studied and evaluated in the application domain through testing. Eliciting requirements from the field testing and the application forms the relevance cycle (Hevner, 2007). The iterative process of examining the design artifact on the foundation of existing scientific knowledge and the derivation of practical and theoretical insights is referred to as the rigor cycle.

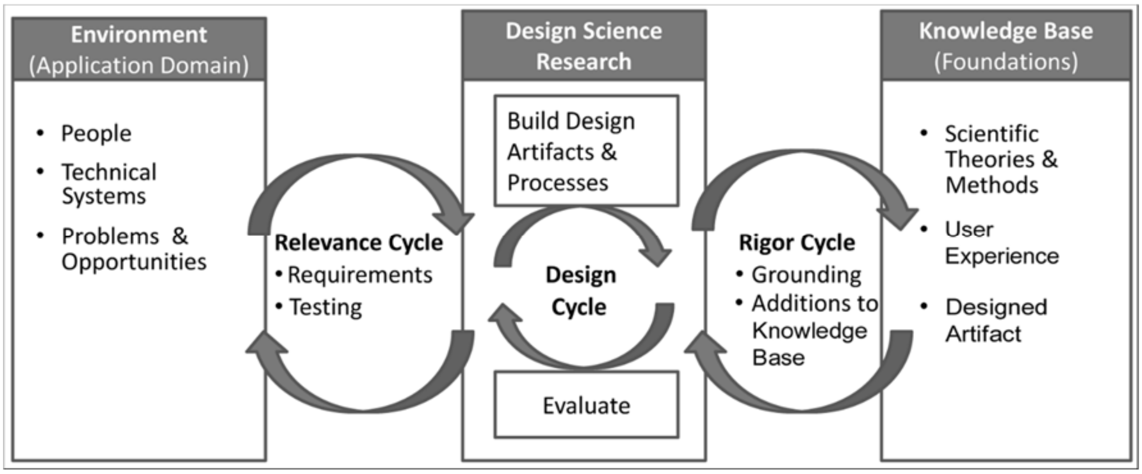

Figure 2 – Design Science Research Cycles, adapted from Hevner (2007)

3 RFID cost calculator design artifact

The development process of the RFID cost calculator is based on the three cycle view (see Figure 2) discussed above. We first elaborate on the problem relevance, followed by a description of the design of the artifact based on existing cost calculation methods adapted to the RFID-context. Subsequently, the evaluation of the artifact is conducted through the use of expert interviews (Myers & Newman, 2007).

3.1 Problem relevance

Let us put forward a scenario that illustrates the importance of cost estimation in anticipation of the RFID system integration process. A medium to large sized retail store includes a storage area with incoming and outgoing goods departments, a sales area, and a point of sale. From the retailer's perspective, RFID can increase efficiency by improving internal product flows, and allows personalized communication with the customer (Loebbecke, 2005). Furthermore, incoming goods equipped with RFID tags can be handled in an automated manner (Rutner et al., 2004) offering the possibility to optimize storage surface, improve inventory visibility and synchronize data with IT-backend systems . Therefore, RFID can support the detection of wrongly located inventory (Maloni & DeWolf, 2006; Richardson, 2004), thus improving product availability (Loebbecke, 2005) and also help with theft prevention measures. Further, at the point of sale, checkout procedures can be accelerated leading to more customer satisfaction, better utilization of store area and a potential to appoint employees differently.

Notwithstanding the aforementioned benefits, short term payoff is uncertain in many cases (Laubacher, Kothari, Malone, & Subirana, 2005) and about 50 percent of all RFID projects fail (Vojdani, Spitznagel, & Resch, 2006). In our example, the retail store has to invest in hardware and software, accompanied by an integration of the RFID components into its existing IT infrastructure (Strueker & Gille, 2008). RFID-system integration costs have significant influence on the success of initial implementation (Maloni & DeWolf, 2006). The approximate percentage of RFID-system integration costs ranges from 22% (Maurno, 2005) to over 80% (Trunick, 2005). However, textbook guidelines for managers are often restricted to general illustrations of RFID technology and system integration costs are only scarcely considered (Angeles, 2005; Karkkainen, 2003).

A model to assess RFID and simulate several scenarios can offer guidance to managers during the project rollout (Asif & Mandviwalla, 2005), and can provide relatively accurate predictions of system integration costs that are essential to the project planning of RFID-projects (Dickson, 2007). While there is some research about cost-benefits of RFID-usage over time (Tsai & Huang, 2012; Uckelmann, 2012), there is little research for quantifying the IT-integration costs for RFID projects in advance. Moreover, the application of conventional cost estimation methods is complex (Boehm, Madachy, et al., 2000) and cannot be applied directly to RFID-system integration projects. Our research fills this gap by designing and evaluating a cost estimation method and tool that takes into account the specific requirements of RFID-system integration projects.

3.2 Prototype design

The RFID cost calculator allows firms to calculate project costs upfront for the integration of a RFID-system into an existing information system environment. The RFID cost calculator considers project attributes and processes, can be adapted according to the existing information systems infrastructure in the organization, and incorporates RFID specific requirements and conditions.

As discussed in the theoretical background section, a RFID system is made up of three layers and comprises several components that contribute towards the cost of the overall project. Many of these components such as the tags, readers, edgeware are standard components that are commercially manufactured, and require very little customization. Therefore, these components can be considered as commercial-off-the-shelf (COTS) components, thus making COCOTS a suitable choice that can serve as a basis for the development of RFID cost estimation method. Further, we drew from various aspects of COCOMO I and COCOMO II in order to develop a comprehensive cost calculation method. Therefore, our method ensures a complete coverage of all RFID-components and systems (see also Figure 1) for an upfront cost calculation. This method was then used as a basis to develop the RFID cost estimation tool prototype.

Steps in the design of the RFID cost calculator

We followed the University of Southern California Center for Software Engineering (USC-CSE) multi-step modeling methodology that has been used for software cost estimation models (Abts et al., 2000; Chulani, 1998). This modeling methodology consists of seven steps, which build on each other and iterate in case of any necessary refinement (see Figure 3).

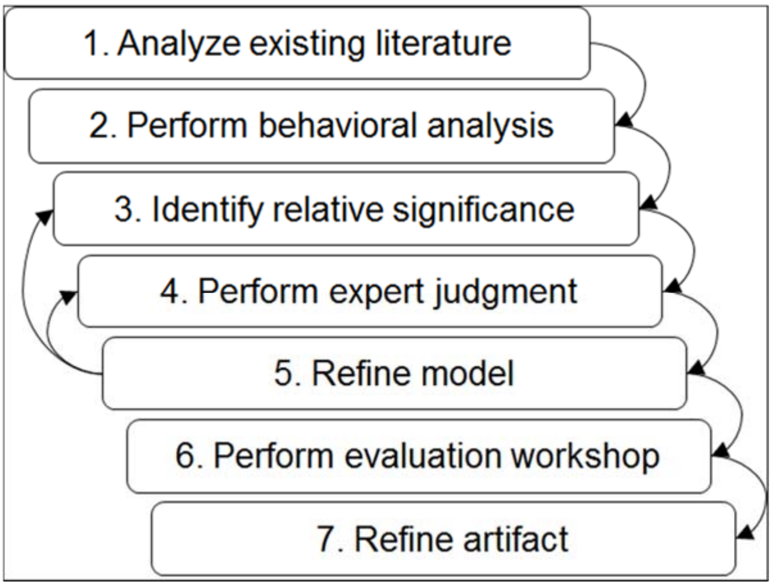

Figure 3 – Steps in the design of the RFID Cost Calculator

As a first step, we reviewed the existing literature in RFID and other auto-identification technology, and software engineering, more specifically software cost estimation. The purpose behind conducting this literature review was to gain an understanding of RFID-systems, their basic infrastructure and the various components involved, and the different kinds of cost calculation methods that are already being used in practice. The next step involved a behavioral analysis. The purpose of the behavioral analysis was to broaden our understanding of existing processes, components, requirements, and cost estimation methods. This was followed by identifying relative significance, i.e., we analyzed current calculation problems and related reasons for failures of RFID-system integration projects. Furthermore, we analyzed factors influencing RFID-system integration, and analyzed the relative significance of the various factors on the overall cost of the RFID integration project, as these would then be incorporated into the cost calculation tool and the cost calculation method.

In a fourth step, we presented our findings regarding the significance of these identified factors to a panel of RFID-experts from the industry. Our experts comprised RFID system-integrators. The experts assisted us in validating the importance of identified processes, components, and methods by providing us with valuable feedback. We then incorporated experts' feedback, and refined the cost calculation model. This was then used as a basis to build the first spreadsheet-based prototype. We finally evaluated the developed prototype in focus group settings with experts, and refined the prototype based on feedback obtained during the focus group evaluations. The iterative development process allowed us to enhance the general usability and validity of the prototype, and ensure its usefulness for practitioners.

4 RFID-CC: A cost calculation method for RFID projects

The five steps in cost calculation are adapted from COCOTS (see Figure 4). While, the initial assessment and the detailed assessment are adapted from COCOTS, we developed the tailoring step from COCOMO I. Furthermore, we adapt the idea of re-usability of existing code including the volatility from COCOMO II. While, the assessment steps are used to select components for the planned RFID-system, the tailoring step links RFID-components with existing IT-systems such as specifying security protocols. Furthermore, the glue code development step is used to program additional code, which incorporates RFID-components and the RFID-system with the existing IT-system including the testing of the code. The volatility step ensures the deployment of new version or updates from vendors. Accordingly, COCOTS allows the combination of economic, technical, and strategic elements together. Therefore, we use COCOTS as base to develop a cost calculation (CC) method for RFID-projects. Figure 4 gives an overview of the adapted RFID-CC method with its phases. In the left column, the different phases of the COCOTS model are depicted, while in the right column the adapted phases of the RFID-CC method are listed. The RFID-CC method is structured along the RFID-components, except the first phase.

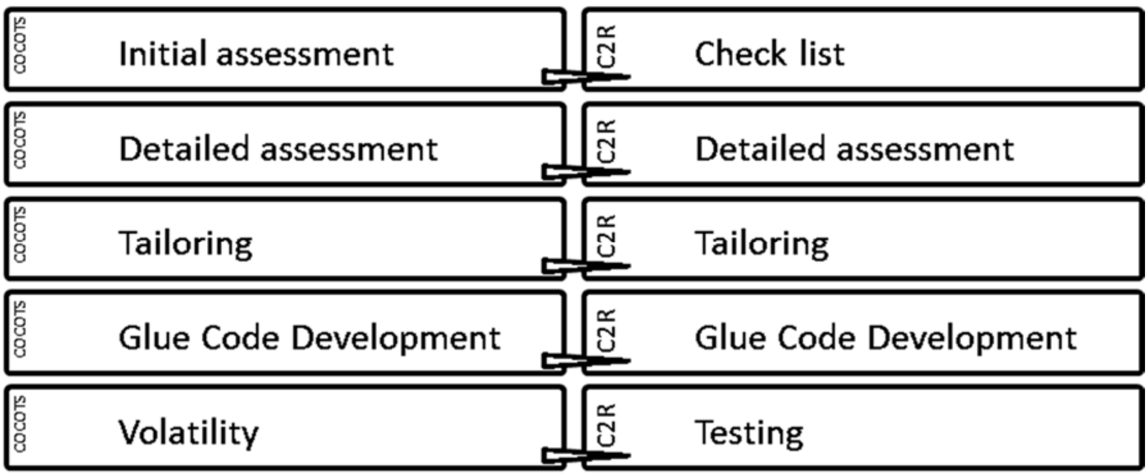

Figure 4 – RFID-CC method and its adaptation from the COCOTS method

Checklist: The first step in the COCOTS method is the initial cost assessment phase to estimate roughly the complete cost for a project. In the case of RFID cost calculation, we propose a slight variation of this step and name it as 'Checklist'. The checklist intends to ensure a complete overview of the RFID-project. More specifically, the checklist helps to get a mutual understanding of existing material and information flows. Furthermore, it supports the definition process of the planned RFID-system with its material flow, information flow, and specific constraints of RFID-systems. Therefore, we modified the initial assessment phase towards a checklist without any cost calculation functions, as our experts indicated the importance of an in-depth RFID-knowledge. According to the experts, this includes an understanding of needed hardware, software, processes, and information systems in order to estimate costs. In consequence, practitioners can gain a better understanding of the existing systems and the expected design of the RFID-system. Therefore, the checklist enables a mutual understanding and awareness of planned changes in the material and information flow. As an addition, our analysis showed that RFID-cost calculations should be preferably lead by experienced people, who have a broad knowledge and understanding of RFID-technology and its cross-disciplines. However, our results also indicate that it is advisable to estimate the costs in a team with mutual goals. Finally, as we did not include any cost function for the initial assessment step, this phase needs to be covered from overhead costs.

Detailed Assessment: The second step in the COCOTS method is the detailed assessment phase. We adapt the detailed assessment towards an estimation of costs to improve the understanding of each RFID-component structured according to the presented RFID-architecture (see theoretical background section). The criteria are the same for all components and include aspects such as security, functionality, or maturity of the component. Therefore, the costs have to be estimated according to the developed criteria for each component such as application server or database server. This detailed assessment process shall enable RFID-project members to acquire sufficient information and competencies to estimate further costs within the next steps. However, we did not include the RFID-infrastructure elements tag and reader for the detailed assessment and tailoring step, as tags and readers profit from their advantage as standard components. In consequence, tags and readers do not add costs for basic implementations, while more specific requirements might lead to costs. Therefore, tags and readers are not excluded in the glue code development step, and the testing step.

The detailed assessment costs are estimated for each component based on the developed criteria. For each criterion, it is necessary to estimate the duration in days and to list the costs per day. This results in costs per criterion (see Formula 1). The costs per criterion will automatically sum up for each component (see Formula 2), and the costs for each component results in the total costs for the detailed assessment step (Formula 3). In case there are no costs, project members can leave the fields blank or insert zero days as duration to document their choice. Figure 5 depicts a screenshot of the developed prototype and illustrates the Detailed Assessment step for one of the components – the connector or edgeware.

$$Costs\ per\ Criterion = (Days) \times (Costs\ per\ Day)$$

Formula 1 - Detailed Assessment - Costs per Criterion

$$Costs\ per\ Component = \sum (Criterion\ 1) + (Criterion\ 2) + (...) + (Criterion\ n)$$

Formula 2 - Detailed Assessment - Costs per RFID-Component

$$Total\ Costs\ Detailed\ Assessment = \sum (Component\ 1) + (Component\ 2) + (...) + (Component\ n)$$

Formula 3 - Detailed Assessment - Total Costs

Components	*Detailed attributes/variants*	Estimation Duration in days	Costs per day	Total costs	decision/result
Connector (Edgeware) Assessment Attributes			0 €		
Correctness	Accuracy, Correctness	0	0 €	0 €	
Availability/Robustness	Availability, Fail safe, Fail soft, Fault tolerance, Reliability	0	0 €	0 €	
Security	Security	0	0 €	0 €	
Performance	Execution performance	0	0 €	0 €	
Ease of Use	Usability	0	0 €	0 €	
Version Compatibility	Downward compatibility, Upward compatibility	0	0 €	0 €	
Intercomponent Compatibility	Compatibility with other components, Interoperability	0	0 €	0 €	
Flexibility	Flexibility	0	0 €	0 €	
Installation/Upgrade Ease	Installation Ease, Upgrade/Refresh ease	0	0 €	0 €	
Portability	Portability	0	0 €	0 €	
Functionality	Functionality	0	0 €	0 €	
Price	Initial purchase costs	0	0 €	0 €	
Maturity	Product Maturity	0	0 €	0 €	
Vendor Support	Response time for critical problems, Support, Warranty	0	0 €	0 €	
Training	User training	0	0 €	0 €	
Total Costs				**0 €**	

Figure 5 – Screenshot for Detailed Assessment in the developed prototype

Tailoring: The third cost estimation step covers the integration of the RFID-system into the existing IT-infrastructure and includes the initial setup and integration steps for the RFID-system. We also structured the cost estimation process according to the presented RFID-architecture (see theoretical background section) and developed criteria for each component. The criteria are developed based on possible roles each component can play or the activities it can perform. Therefore, we have different amounts of criteria per component. The cost estimation process does not differ between the components and is similar to the introduced process in the tailoring step. However, we implemented a simple and advanced cost calculation process, as requested during the evaluation.

Within the simple cost calculation process, each criterion needs to be multiplied with the expected duration (hours) and the hourly rate resulting in costs per criterion (see Formula 4). This allows to automatically sum up the costs per component (see Formula 5). Further, the costs per component result in the total costs for the tailoring step (Formula 6). In case there are no cost, project members leave the fields blank or add zero hours as indication for their choice.

The advanced cost calculation process is the same, however, some functionalities are developed for experienced users. For example, imagine an IT-department with RFID-specialists who provide a cost calculation sheet as template for their firm: To support RFID-projects, the project members can simply use bars within the prototype to indicate the level of difficulty of processes (represented by the criteria). The bars represent five levels. The first level represents the shortest time, indicating experienced users or project teams, while the fifth group represents the opposite. By using the bars, the prototype calculates the needed hours. This is done by multiplying hours with an hourly rate. Therefore, the RFID-specialists have to pre-estimate the needed hours for each of the five levels. If the pre-estimation is done, the user calculates the costs per criterion by simply using the bars, while the duration is based on the estimation of the RFID-specialists. Accordingly, the advanced calculation process can either be used internally from RFID-specialists who implement RFID-systems more often or as support functionality within a firm. Figure 6 represents a screenshot of the Tailoring assessment step within our prototype. It illustrates the simple and advanced cost calculation processes for the connector or edgeware and messaging server or middleware.

$$Costs\ per\ Criterion = (Days) \times (Costs\ per\ Day)$$

Formula 4 - Tailoring - Costs per Criterion

$$Costs\ per\ Component = \sum (Criterion\ 1) + (Criterion\ 2) + (...) + (Criterion\ n)$$

Formula 5 - Tailoring - Costs per RFID-Component

$$Total\ Costs\ Tailoring = \sum (Component\ 1) + (Component\ 2) + (...) + (Component\ n)$$

Formula 6 - Tailoring - Total Costs

Components	*Detailed attributes/variants*	Estimation Duration in days	Costs per day	Total costs	decision/result
Connector (Edgeware) Assessment Attributes			0 €		
Correctness	Accuracy, Correctness	0	0 €	0 €	
Availability/Robustness	Availability, Fail safe, Fail soft, Fault tolerance, Reliability	0	0 €	0 €	
Security	Security	0	0 €	0 €	
Performance	Execution performance	0	0 €	0 €	
Ease of Use	Usability	0	0 €	0 €	
Version Compatibility	Downward compatibility, Upward compatibility	0	0 €	0 €	
Intercomponent Compatibility	Compatibility with other components, Interoperability	0	0 €	0 €	
Flexibility	Flexibility	0	0 €	0 €	
Installation/Upgrade Ease	Installation Ease, Upgrade/Refresh ease	0	0 €	0 €	
Portability	Portability	0	0 €	0 €	
Functionality	Functionality	0	0 €	0 €	
Price	Initial purchase costs	0	0 €	0 €	
Maturity	Product Maturity	0	0 €	0 €	
Vendor Support	Response time for critical problems, Support, Warranty	0	0 €	0 €	
Training	User training	0	0 €	0 €	
Total Costs				**0 €**	

Figure 6 – Screenshot for Tailoring in the developed prototype

Glue code development: The fourth step estimates costs for the development of new code in case further functionalities are requested, the provided code is not sufficient or even no code is available. Therefore, the developed code can be expected to be unique for one RFID-project. Based on our evaluation, we extracted the testing of the glue code and created an own step within our RFID-CC. Therefore, our glue code development step only refers to the development of code. Glue code development might become necessary in case additional functionalities are requested and cannot be covered during the system integration phase. Further examples are the integration of RFID into supply chain networks, as different systems within the network complicate the data transfer among firms. Moreover, internal requests such as additional possibilities to analyze data influence the amount of needed glue code. In consequence, many influences have to be covered during the code development. Therefore, we created three eight by eight matrix. For each component, up to nine different connections can be setup, while more connections can be added. This results in more than 1.800 possible interfaces between the components. Therefore, RFID-projects can estimate costs for many different purposes.

The first matrix gives users the possibility to indicate whether they want to develop glue code or not, and in case code needs to be developed the user has to estimate the needed lines of code (LOC). For the second matrix, the estimated duration (in minutes) per line needs to be filled out. As an addition, the hourly rate for the code developer has to be defined. As an addition, we incorporated an influence factor due to the feedback during the evaluation phase. The influence factor allows to "fine-tune" the cost estimation process. This might be necessary in situations such as firms have new developers or the developer first needs to be trained in a new programming language. Finally, the costs per interface will be automatically calculated based on the input. Furthermore, the matrix provides the total costs for the complete code development process (see Formula 7). Figure 7 represents the Glue Code assessment step of our prototype for the connector or edgeware and messaging server or middleware components. In specific, Figure 7 illustrates the first matrix of the Glue Code development for up to nine functionalities.

$$Total\,Costs\,Glue\,Code\,Development = \sum (\#\,LOC) * (Duration\ per\ LOC) * (Hourly\,Rate) * (Influence\,Factor)$$

Formula 7 - Glue Code Development - Total Costs

Components	*Detailed attributes/variants*	Estimation Duration in days	Costs per day	Total costs	decision/result
Connector (Edgeware) Assessment Attributes			0 €		
Correctness	Accuracy, Correctness	0	0 €	0 €	
Availability/Robustness	Availability, Fail safe, Fail soft, Fault tolerance, Reliability	0	0 €	0 €	
Security	Security	0	0 €	0 €	
Performance	Execution performance	0	0 €	0 €	
Ease of Use	Usability	0	0 €	0 €	
Version Compatibility	Downward compatibility, Upward compatibility	0	0 €	0 €	
Intercomponent Compatibility	Compatibility with other components, Interoperability	0	0 €	0 €	
Flexibility	Flexibility	0	0 €	0 €	
Installation/Upgrade Ease	Installation Ease, Upgrade/Refresh ease	0	0 €	0 €	
Portability	Portability	0	0 €	0 €	
Functionality	Functionality	0	0 €	0 €	
Price	Initial purchase costs	0	0 €	0 €	
Maturity	Product Maturity	0	0 €	0 €	
Vendor Support	Response time for critical problems, Support, Warranty	0	0 €	0 €	
Training	User training	0	0 €	0 €	
Total Costs				**0 €**	

Figure 7 – Screenshot for Glue Code in the developed prototype

Testing: The last step is testing. The testing step is used to ensure a stable RFID-system. The prototype automatically transfers all selected interfaces during the glue code development step towards the testing step. Therefore, the prototype provides an automatic indication of additional testing effort. As testing was mentioned as crucial step for RFID-projects, we organized the glue code testing process as own process in contrast to the COCOTS method. Further, we did not integrate the volatility step from COCOTS, as we learned that RFID-projects end by implementing the RFID-infrastructure and its software. Updates and modifications are considered as new projects.

In consequence, the test costs are derived from the chosen glue code connections. Our prototype allows for filtering of the relevant connections and can calculate the test costs with up to three iterations. In a first step, the user needs to indicate whether there shall be a testing or not. If testing is required the user has to estimate the test loops (from one to three), and for the first test loop the duration and the hourly rate (Formula 8). If there is more than one test loop, it is necessary to indicate the duration and hourly rates for the other test loops. The duration in the second and third test loop has to be specified in percentage using the initial time for the first test (Formula 9). Based on the amount of test loops, the duration, and the hourly rate, our prototype calculates the total test costs (see Formula 10). Figure 8 is a screenshot of the developed prototype and illustrates the Testing step for two functionalities. The first functionality depicts the need for two optimization cycles, while the second functionality only needs one optimization. As an addition, if a functionality needs an optimization cycle, the fields, which need to be filled, become yellow.

$$Test\ Costs\ Loop\ 1 = Duration * Hourly\ Rate$$

Formula 8 – Testing – Test Costs Loop 1

$$Test\ Costs\ Loop\ 2\ or\ 3 = (Duration\ Test\ Loop\ 1 * (Duration\ Test\ Loop\ 2\ or\ 3)/100) * Hourly\ Rate$$

Formula 9 – Testing – Test Costs Loop 2 or 3

$$Total\ Test\ Costs = \sum [(Test\ Loop\ 1) + (Test\ Loop\ 2) + (Test\ Loop\ 3)] * Hourly\ Rate$$

Formula 10 – Testing – Total Test Costs

Components	*Detailed attributes/variants*	Estimation Duration in days	Costs per day	Total costs	decision/result
Connector (Edgeware) Assessment Attributes			0 €		
Correctness	Accuracy, Correctness	0	0 €	0 €	
Availability/Robustness	Availability, Fail safe, Fail soft, Fault tolerance, Reliability	0	0 €	0 €	
Security	Security	0	0 €	0 €	
Performance	Execution performance	0	0 €	0 €	
Ease of Use	Usability	0	0 €	0 €	
Version Compatibility	Downward compatibility, Upward compatibility	0	0 €	0 €	
Intercomponent Compatibility	Compatibility with other components, Interoperability	0	0 €	0 €	
Flexibility	Flexibility	0	0 €	0 €	
Installation/Upgrade Ease	Installation Ease, Upgrade/Refresh ease	0	0 €	0 €	
Portability	Portability	0	0 €	0 €	
Functionality	Functionality	0	0 €	0 €	
Price	Initial purchase costs	0	0 €	0 €	
Maturity	Product Maturity	0	0 €	0 €	
Vendor Support	Response time for critical problems, Support, Warranty	0	0 €	0 €	
Training	User training	0	0 €	0 €	
Total Costs				**0 €**	

Figure 8 – Screenshot for Testing in the developed prototype

5 Prototype evaluation

5.1 Theory and research methodology

An important step in design science research is the evaluation of the designed artifact (Hevner, 2007). The RFID cost calculator was developed to increase the upfront cost estimation accuracy of RFID-system integration projects. Therefore, the goal of the prototype evaluation is to assess the extent to which the RFID cost calculator allows for a more accurate estimation of RFID system integration costs taking into account the technical and functional elements of a RFID-system and its cross-functional requirements.

We drew upon previous research to identify relevant methodologies that can be used for the evaluation of our prototype. We also tried to ensure that the evaluation methodology used, allowed us to evaluate our artifact's fit in the context of information systems, supply chain and RFID. We therefore chose the cognitive walkthrough methodology, which is recommended for practicing software developers without background in cognitive psychology and only some experience in interface evaluation. The cognitive walkthrough methodology enables practicing software developers to examine their artifact and identify subtle problems (Wharton, Rieman, Lewis, & Polson, 1994). We further decided to use the "cognitive walkthrough with users" variant (Mahatody, Sagar, & Kolski, 2010), which can be considered as helpful in the case of a complicated cross-functional domain like RFID (Granollers & Lorés, 2006). Applying this variant of cognitive walkthrough enables us to uncover mismatches between implicit and explicit expectations of users by incorporating the three phases (Granollers & Lorés, 2006; Wharton et al., 1994). Therefore, we consider the "cognitive walkthrough with users" methodology as a well suited approach (Mahatody et al., 2010; Wharton et al., 1994).

The cognitive walk through process is structured in three main phases. The first phase defines the input for the cognitive walkthrough methodology (Wharton et al., 1994). This includes (1) the choice of representative users (Granollers & Lorés, 2006; Wharton et al., 1994), (2) a definition of tasks for the evaluation (Wharton et al., 1994), (3) the planned action sequence in the prototype (Wharton et al., 1994) and (4) a definition of the interface (Wharton et al., 1994). In the second phase, the users are invited to perform the tasks defined in the first phase. During the evaluation process, users are asked to express aloud their thoughts, feelings, and opinions (Granollers & Lorés, 2006). In consequence, researchers can use this direct feedback as second source to improve the prototype. As primary source, researchers analyze observational data, which needs to be collected during the evaluation process (Wharton et al., 1994). Furthermore, users are asked to comment on detected deficiencies more in detail after each sequence (Granollers & Lorés, 2006). In the third phase, experts review the collected data to improve the prototype (Granollers & Lorés, 2006).

In the second phase, we conducted semi-structured interviews (Myers & Newman, 2007) after each sequence to refine and strengthen the usefulness of our evaluation data, and ensure the inclusion of cross-functional aspects of RFID-projects. As semi-structured interviews are a powerful gathering technique, it is often used in the field of IS due to its flexibility, and allowed us to explore relationships in this cross-functional field (Myers & Newman, 2007).

Ensuring a proper evaluation setting, we provided a prototype, supported by a fictional case study about RFID-system integration within the retail industry (Wharton et al., 1994). The evaluation was recorded (Lewis, Polson, & Rieman, 1991; Wharton, 1992; Wharton, Bradford, Jeffries, & Franzke, 1992) and analyzed according to the semi-structured interview guidelines from Myers and Newman (2007).

5.2 Setup of the evaluation

The evaluation process was split into two sets. Both sets – experts and focus group – were evaluated using the cognitive walkthrough method. Further, the workshop combined the guidelines from Ericsson and Simon (1993) and Browne and Rogich (2001), allowing us to collect and to properly analyze the feedback after each cost calculation step.

The first data set consisted of two expert interviews enhancing us to get detailed insight and feedback for our prototype. Employing theoretical sampling, rather than random sampling allowed us to interview two experts in the field of RFID (Corbin & Strauss, 2008), supporting our intention to include cross-functional aspects. The identified experts were system integrators, ensuring professional and technical knowledge in all cross-functional disciplines (RFID, IS, Project Management). As RFID is not specific to an industry, we paid attention to practical experience of our experts, declaring in each expert having more than 10 years of experience with RFID, more than 23 years of industry experience and each conducted more than 36 RFID-projects.

The second part of the evaluation was conducted with a focus group, ensuring usefulness of the artifact for the cross-functional target audience. All focus group participants were classified as potential adopters (Karahanna, Straub, & Chervany, 1999), i.e., specialists who had knowledge of RFID but had not implemented RFID, and potential users. Seven individuals participated in the focus group. All participants were male and ranged in the age from 27 to 53, with an average of 42 years. 57% held a master's degree, 29% held a bachelor's degree, while 14% held a diploma for three year training on the job. Participants' average experience in the industry was 17.1 years, while their average RFID experience was 7.4 years. 71% of the participants had knowledge in information systems and already conducted some information system integration projects, 86% stated they had project management knowledge and all of them confirmed knowledge in the field of RFID. The participants are from the fields of supply chain management and information systems. While three employees are on an operational level, four employees are on the managerial level.

In case of the experts, we sat beside them, introduced them to each of the cost estimation steps in short and explained them the task such as calculation of tailoring costs. While the experts tried to achieve their given task, we noted their problems and discussed the problems with the experts after each step. One expert was interviewed in a meeting room at the university, whereas the second expert was interviewed within his company. The first interview lasted one and a half hour, whereas the second interview was held in one hour. Both interviews were conducted in the same logical order and structure, applying the cognitive walkthrough method. We handed the fictional case study to our first expert, starting with the second phase of the cognitive walkthrough, collecting comments from the expert, noting observations and using our semi-structured interview questionnaire to clarify open issues and problems for our understanding. We supported the experts during the cognitive walkthrough in case we uncovered a mismatch between our implicit assumptions of the RFID cost calculator usage and issues experienced by our experts. Furthermore, we briefly introduced each sequence before our expert started with it. After the first expert judgment, we analyzed the transcript and our observational data, which allowed us to modify our prototype before the second expert tested the prototype. The process resulted in a more sophisticated prototype based on two iterative improvements underlying our analysis data.

With the focus group, we proceeded in a similar manner. The focus group evaluated our prototype in a workshop, which lasted for about one a half hour. The workshop was prepared and led by one of the authors. Further, one independent researcher supported the walkthrough process with the focus group. First, we introduced the general topic, the fictional case study as base for the test and briefly the cost calculation steps of the prototype. Second, the participants had twenty minutes to solve the fictional case study. We asked them to give us their feedback about the usefulness of the sequence, the cost estimation process, and their experience of the user-interface, and to comment on deficiencies after each sequence (Granollers &

Lorés, 2006). In a further step, we walked with the participants through the prototype, explaining the participants our idea of the process. Fourth, we briefly discussed the differences and noted the problems the participants experienced within each cost estimation step. Fifth, we asked the focus group to redo the cost calculation before we finally had an open discussion. While there was no need to modify the elaborated RFID-CC cost calculation method (see prototype design section), we refined our prototype based on our design rationales and the collected data.

5.3 Analysis and Findings of the evaluation

The first prototype was based on literature, mainly derived from COCOMO I, COCOMO II and COCOTS. Therefore, the RFID cost calculator included the phases (1) initial assessment, (2) detailed assessment, (3) tailoring, (4) glue code development and (5) volatility. The final RFID cost calculator includes a (1) checklist, (2) detailed assessment, (3) tailoring, (4) glue code development and (5) testing. The development and evaluation of the tool was around nine months.

As RFID projects differ even within the same company, we modified the initial assessment phase towards a checklist (1) to document existing material and information flow processes, services and functions, and (2) plan the requirements for the target processes, services and functions. In consequence, the initial assessment phase has to be covered by overhead costs and contributes by supporting the completeness of aspects in the cost calculation process.

Major changes in the detailed assessment phase are the removal of RFID reader and RFID tag towards the checklist. This is grounded on the reason of RFID (system integration) projects itself, as it is seen as mandatory to acquire knowledge about tags and readers in advance. Furthermore, the estimation unit has been changed from hours to days, and an easier process for cost entries has been established.

The tailoring phase has been adapted closely from the COCOTS model and includes the same attributes and infrastructure classes like the detailed assessment phase. However, we adapted the tailoring phase for experienced users and repeating calculations (advanced version), and for un-experienced users and non-repeating calculations (simple version). In consequence, the easier version can also be used for scenarios in which services are bought from 3rd parties, while the more difficult version contributes, i.e., to a higher standardization such as in large enterprises with special departments dedicated to RFID projects, or RFID service providers.

The glue code development phase has undergone an extension from a simple matrix towards a matrix consisting out of more than 550 fields. Furthermore, the matrix has been cloned two times, leading to the total of 3 matrixes with more than 1.800 fields. The main drivers for the change are the extension of processes, service and functions into the calculation scheme. Further, the RFID cost calculator now allows users to adjust the calculation with an influence factor requested by the focus group. The influence factor can be used for many purposes such as adjusting the knowledge of the programming language, new project members (learning curve), or supply-chain-wide usage of RFID. Moreover, the matrix of the RFID cost calculator can be extended in case more than nine connections within one RFID-infrastructure class are needed.

The testing phase was conducted after the first expert interview. We got the understanding that RFID system integration projects are treated like normal business projects implying project termination after completion. Therefore, RFID system integration projects are finished shortly after launch. In case of further requirements, firms will setup a successive project and do not treat issues as volatility. Furthermore, we integrated a filter for better manageability of the over 1.800 fields, based on the feedback from our second expert.

Overall, based on the interview notes and the group discussion, it can be stated that the reviewers found our cost calculation tool to be helpful for estimating costs for RFID system integration projects in advance before the actual start of the project. For instance, our reviewers indicated that it was particularly helpful to be able to incorporate off the shelf components in the overall cost estimation, and could incorporate scenarios where certain integration and implementation services are acquired from third party service providers. Therefore, the use of our prototype and formulas contribute to a more effective cost estimation process ahead of starting a RFID-project. This will also help firms to realize a faster return-on-investment.

6 Discussion

Current research and practical developments in RFID technology reflect the potential of RFID in the field of supply chain management (Rutner et al., 2004) and advantages of RFID over traditional auto-ID technologies (Thiesse, 2005; Want, 2006). The potential has been demonstrated in industry projects (Cocca & Schoch, 2005; Ming-Ling Chuang & Shaw, 2007) and analyzed from a research perspective (Holmqvist & Stefansson, 2006; Tzeng, Chen, & Pai, 2008). However, the introduction of RFID systems in the processes of firms is often forced by the stronger supply chain partner (Ming-Ling Chuang & Shaw, 2007). This reserved behavior of firms can be explained by skepticism to reach an early break-even point and the possibility to generate value (Ming-Ling Chuang & Shaw, 2007; Vijayaraman & Osyk, 2006). Further constraints are different risk factors such as technology maturity, availability of expertise and most importantly from an economical perspective the cost to value ratio (Fontanella, 2004).

While there is research about how to measure the benefits of RFID systems after their implementation (Tsai & Huang, 2012; Uckelmann, 2012), the challenge to estimate RFID system adaptation costs for the integration into an existing IT landscape beforehand has been scarcely addressed (Asif & Mandviwalla, 2005). The design and evaluation of the RFID cost calculator aims to fill this gap through the development of a RFID cost calculation approach and an applicable tool which covers the implementation steps and requirements of RFID systems, and therefore enhances firms to calculate costs more appropriately for RFID system integrations in advance.

Our study further contributes to IS research by showing the applicability of the cognitive walkthrough method in the context of cost calculation tools. Furthermore, we developed an upfront cost calculation method for RFID-system integration projects using previous research from the fields of software cost calculation, supply chain management and RFID. Moreover, our evaluation indicated that regardless of whether participants were experts or not, they considered our RFID cost calculator as a useful tool to estimate RFID-system integration costs more accurately, resulting in a satisfaction with the tool and the intention to use it. This gives direct validation to the claim that our tool addresses the expectations of users. In addition, this also validates the applicability for small and medium sized enterprises as well as for internationally acting firms.

In the current study, we developed a RFID cost calculation tool and analyzed the usefulness, satisfaction and the intention to use the RFID cost calculator. In fact, while this study was primarily concerned with the development with a RFID system integration cost calculation approach and evaluating the prototype, future research can investigate the correctness of our formulas including the usability in a practical scenario, given that the tool is derived from three different fields.

7 Limitations and Implications for future research

The RFID cost calculator, as well as the evaluation study should be interpreted in the context of its limitations. The developed RFID cost calculator is an initial approach to calculate system integration costs more accurately beforehand. However, RFID-projects always differ and therefore new challenges might occur, which are probably not addressed in the current version of the cost calculator tool.

The RFID cost calculator was developed based on practical relevance claiming that current RFID projects miss their economic goals (Straube, 2009; Thiesse, Al-Kassab, & Fleisch, 2009; Vojdani et al., 2006). This holds particularly true for inter-organizational supply chains, as the general project risk level increases (Fontanella, 2004) and economic and socio-political aspects occur (Kumar & van Dissel, 1996; H. Lee, Padmanabhan, & Whang, 1997), reflecting the need for incentive alignment (Barzel, 1997; Klein & Rai, 2009). Therefore, the RFID cost calculator allows firms or supply networks to calculate RFID system integration costs beforehand for internal projects and also for inter-organizational projects. In consequence, the RFID cost calculator enhances to reduce the overall RFID project risk due to a more accurate cost calculation in advance. Moreover, based on a more precise calculation supply networks can align economic aspects and further RFID-project related incentives. The increasing amount of RFID implementations (L. Lee et al., 2008; Sarac, Absi, & Dauzère-Pérès, 2010), its analysis from a research perspective (Ngai, Moon, Riggins, & Yi, 2008; Sellitto, Burgess, & Hawking, 2007; Thiesse & Condea, 2009) and its introduction in the area of consumers (Bamasak, 2011; Dahlberg, Mallat, Ondrus, & Zmijewska, 2006; Engel et al., 2012; Köbler, Goswami, Koene, Leimeister, & Krcmar, 2011; Michael & Michael, 2010; Ondrus & Pigneur, 2005, 2007) indicate the growing importance and popularity in the society. Therefore, future research endeavors may be targeted towards the verification of the RFID cost calculator and its extension and usability in different use contexts. Further, research could investigate the use in a field study.

Using the cognitive walkthrough methodology to evaluate the cost calculator results in limitations that are inherent to this research methodology. Future studies could assess the different phases from an observational setting or post-perspective setting where users are less likely to feel constrained by conducting field experiments. In our evaluations, a fictional case study was used to evaluate the prototype. While this fictional case study might not cover all constraints of specific RFID-projects, it can be considered sufficient for the evaluation and acceptance of the RFID cost calculator in general RFID-projects. However, future studies that allow RFID-adopters to use and evaluate the RFID cost calculator over a longer period of time could be designed to get a better gauge of missing aspects and first-hand experiences with the cost calculator and their willingness for a continuous usage of the tool. Furthermore, conducting expert interviews and run focus group evaluations to assess a prototype is appropriate in a field with limited research results (Corbin & Strauss, 2008; Yin, 2009), and therefore the use of experts and focus groups does not raise serious concerns in this study. Further, our experts and the participants of the focus group were generally reflective for RFID-projects as all subjects had experience with RFID and supply chain management.

8 Conclusion

In spite of the growing popularity of RFID-technology in the field of supply chain management, and an observed trend towards usage within the society (Bamasak, 2011; Ondrus & Pigneur, 2007), currently, there is little theoretically grounded understanding of the cost-drivers for the integration, and the integration costs of RFID-systems into an existing IT-landscape of firms. Identifying this gap, we conceptualized a cost calculation tool for a more accurate calculation of RFID-system integration costs in advance of implementing RFID-projects, and assessed the extent to which the RFID cost calculator allows estimating system integration costs more accurately; considering the technical and functional elements of a RFID-system and its cross-functional requirements.

We developed the RFID cost calculator as first approach in a research context. The prototype allows users to calculate costs in advance of the implementation of a RFID-system into an existing IT-landscape. Further, the cost calculator can be applied for internal and inter-organizational cost calculations. In this paper, we derived a new cost calculation method from literature to identify and assign RFID-system integration costs. In a successive step, we outlined the design of the RFID cost calculator, along with an evaluation of the tool using the "cognitive walkthrough method with users" in a laboratory setting, supported by interviews and open discussions. The findings suggest that prospective users perceive the prototype as useful and are satisfied with it. Further, they indicate an intention to use the prototype if it is available to them.

Our results further indicate that RFID-experts and users confronted with RFID-technology in the field of supply chain management perceive the cost calculator as useful and are satisfied with it. This indicates that there is significant need to calculate costs more accurately upfront for RFID-systems from diverse perspectives in conjunction with completeness of RFID-infrastructure attributes. For instance, being able to calculate costs in a standardized manner may be particular useful for big firms, who have the opportunity to centralize RFID-knowledge; while smaller firms need more flexibility in their calculation. Thus, the flexibility provided by the RFID cost calculator can be thought of as the opportunity to integrate service providers, who implement certain aspects of an RFID-system due to missing knowledge at the responsible contractor. Further, standardization can be useful for centralized departments, in charge and control of firm-wide RFID-implementations. Future research could therefore assess the need for further mechanism to support standardization and flexibility aspects for users in charge of RFID-implementations. Finally, more comprehensive, long-term studies should be designed and executed to assess the extent to which different user groups find the application useful and how its usage influences the accuracy of RFID-system integration calculations.

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Publication 9

Value Creation in Pharmaceutical Supply Chains using Customer-Centric RFID Applications

Title	Value Creation in Pharmaceutical Supply Chains using Customer-Centric RFID Applications	
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Abstract

This study proposes an approach towards generating value in pharmaceutical supply chains using radio frequency identification (RFID) technology. The approach focuses on the relationship between pharmacies, customers, and manufacturers. Multiple explorative case studies were conducted and analyzed to identify potential areas for improvement in the supply chain (SC), and means of customer integration supported with Near Field Communication (NFC) devices. NFC is a standard for radio frequency communication between smartphones and related NFC devices, and allows data exchange between devices that are in close proximity (within a four inch area). Our findings allowed us to explore novel use-cases based on NFC and RFID technologies and their applications to enhance value realization in the downstream pharmaceutical SC.

Individual contribution from Tobias Engel: My contribution is the idea for this research project, guidance during the case study, supporting the coding process, providing relevant literature, suggesting the structure for the paper, and doing the write-up of the paper based on the first English version. Further, I addressed the review comments, and re-submitted the final version of the paper.

1 Introduction

This study analyzes the application of radio frequency identification (RFID) in the health care industry, since there is reason to believe that the application of RFID in healthcare will significantly increase in the next decades (Fichman, Kohli, & Krishnan, 2011). One of the reasons is that an ageing society in industrialized countries (Samuel Fosso Wamba, 2011) will significantly increase the demand for health care products and services, further worsen by increasing purchasing power and living standards in non-industrialized countries. For example, within the next five years, the gross domestic product per capita in the People's Republic of China alone is estimated to increase by approximately 60 percent, resulting in an overall growth of the Chinese purchasing power (International Monetary Fund, 2011). The last century has shown that such a development is, in most cases, accompanied by an increase in demand for health care (Baltagi & Moscone, 2010). In addition, the changing demographics in Western countries heavily influence the health care systems. By 2060 over 34 percent of the German population will be 65 years and older, compared to 20 percent in 2008 (Statistisches Bundesamt, 2009). The increase of the portion of the elderly on the overall German population will result in a rising demand for health care, including medication. These developments illustrate the significance of health care in the future and also imply the necessity of its efficient management. Accounting for 31.1 billion Euro and therefore approximately for 19 percent of the total health care spending in Germany in 2010, the pharmaceutical industry is one of the cornerstones of the health care system (AOK Bundesverband, 2011). Accordingly, it is important to increase efficiency and to develop new approaches and concepts to enhance value realization in the pharmaceutical supply chain (SC).

This study proposes requirements for a RFID-based solution for the transaction of medication related services between patients and pharmacies. Firstly, a literature review on RFID technology and its application in the pharmaceutical SC is conducted. Using a case study approach, we conduct multiple explorative case-studies in German pharmacies to understand their upstream and downstream SC. Based on the findings of the cases, we propose a conceptual approach for enchancing downstream pharmaceutical SC based on the application of RFID technology. The paper concludes with a discussion of limitations and implications of this study.

2 Literature Review

Substantial research has been conducted on the way RFID technology can be used to positively influence SC (Kambil & Brooks, 2002), (Agarwal, 2001) (Agarwal, 2001), (Tellkamp, 2006). First and foremost, RFID technology is capable of delivering real-time information on the status of any given RFID-tagged object in the SC (Sarac, Absi, & Dauzère-Pérès, 2010). This data can be stored online or directly on the RFID tag (Wiles, 2007). By providing this additional information, RFID enables the implementation of efficient processes in every area of the SC (Delen, Hardgrave, & Sharda, 2007). Furthermore, with an increased information transparency throughout the entire SC, firm and SC performance can be improved (Rai, Patnayakuni, & Seth, 2006), i.e., stock levels can be lowered and costs can be reduced (Wang, Liu, & Wang, 2008). Additionally, increased traceability allows avoiding stock-out situations

(Fleisch & Tellkamp, 2005) and mark-down of products can be prevented (Goswami, Ravichandran, Teo, & Krcmar, 2011). Moreover, RFID systems can be used to track (Vacca, 2009) and enrich tagged products during the handling process at each supply chain member with additional information (Ngai, Cheng, Au, & Hung Lai, 2007), i.e., dosage of drugs, in comparison to the currently used bar code system. Making use of RFID technology, enhances firms, in case of a call-back (Seelbinder, 2010), (Huang, Qin, Qu, & Dai, 2010) to track the faulty products, disposing only affected products and preventing the entire production lot from being destroyed. Additionally, for some pharmaceutical products certain conditions need to be ensured, such as medication that needs to be stored at a certain temperature (World Health Organization, 2003). RFID tags can be combined with sensors (Blecker & Huang, 2008), permitting the supervision of all events within the pharmaceutical SC and ensuring proper handling. Similarly, monitoring the expiry date can be carried out, guaranteeing the promised effect and avoiding the mark-down and disposal of expensive drugs.

In addition, a major problem in the pharmaceutical industry is the widespread dispersal of counterfeit products. Due to its better security standards, in comparison with barcodes, usage of the RFID technology allows to secure the SC more effectively, increasing the value for all SC members by preventing patients taking counterfeit products and companies loosing revenues (Chien, Yang, Wu, & Lee, 2011), (Lehtonen, Michahelles, & Fleisch, 2007), (Wyld, 2008). According to the World Health Organization, between five and eight percent of the pharmaceuticals traded in the world are counterfeit (Koh, Schuster, Chackrabarti, & Bellman, 2003). Although being mainly a problem in non-industrialized countries, counterfeit pharmaceuticals find their way into Western societies as well. Apart from the severe economic losses for the drug manufacturers, the use of counterfeit drugs is accompanied by severe health risks (Mukhopadhyay, 2007). With a unique identification code stored on the RFID tag on the packaging of the medicine, it is believed that counterfeiting can be contained to a large extent.

Theft and shrinkage of drugs and medicine is another problem in the pharmaceutical SC, especially in large institutions like hospitals, with a large inventory turnover and many employees with access to the supplies (Dutta, Lee, & Seungjin, 2007), (Auer, Bick, Kabisch, & Kummer, 2010). As in the case of counterfeiting, drug theft results in financial damages, possible stock-out situations, and severe health risks (Rekik, Sahin, & Dallery, 2009).

The benefits of RFID are accompanied by some heavily discussed drawbacks. First of all, there are many concerns about RFID violating people's privacy (Kapoor, Zhou, & Piramuthu, 2009). In the health care sector in particular, RFID offers the possibility of storing very intimate information about the patient. Although measures have been taken to prevent misuse of this data by encryption, there are still concerns (Clampitt, 2007). Secondly, there have been some discussions about the profitability of a RFID system (Kumar, Swanson, & Tran, 2009). Even though prices of RFID tags and systems are expected to decrease in the future (Subramanian et al., 2005), a realiable economic analysis should always be accomplished.

Regarding the fact that an estimated 31 percent of healthcare providers' annual operating costs are spent to support SC activities, RFID-induced costs seem to be economically justifiable, considering the benefits they may yield (Bendavid, Boeck, & Philippe, 2011). Additionally, tag prices have to be considered in relation to value of goods in the pharmaceutical SC. Current analyses have shown that average drug retail prices in Germany range from 20 € to

110 € (progenerika, 2010), considering a RFID tag price of five Euro cent, tagging drugs at an item-level represents less than one percent of the retail-price of pharmaceuticals (RFID Journal), (Straube, Vogeler, & Bensel, 2007), (Thoroe, Melski, & Schumann, 2009). Considering the ratio and the benefits of RFID, the assumption of item level tagging in the pharmaceutical SC can be regarded as realistic. Nevertheless, various papers proclaim that a major problem for the implementation of an RFID system is the allocation of costs for the RFID tags among the SC members (Whang, 2010). Cost allocation and incentive sharing are important aspects of projects that focus on RFID integration in the SC and have to be considered to ensure economic benefits and profitability (Cachon & Lairiviere, 2001), (Narayanan & Raman, 2004). While extensive research has been conducted in this area, this paper, in contrast, analyzes the downstream SC and develops a conceptual approach to generate value at the interface between pharmacies and customers. Consequently, our multiple explorative case studies focus on aspects contributing to value in pharmaceutical SC, through the use of RFID technology.

3 Methodology

This study uses a multiple single-unit explorative case study approach to obtain detailed information about the current SC processes at German pharmacies. A case study is an empirical inquiry, able to cope with a variety of evidence and ability to produce qualitative research results (Yin, 2009). We used semi-structured interviews, as this technique is a powerful method to gather information (Myers & Newman, 2007). Considering the guidelines from Myers (Myers & Newman, 2007), we developed and conducted semi-structured interviews. Prior to administering the semi-structured interview guideline, they were checked for validity by two independent researchers not involved in the research. In total, the interview guideline consisted out of 45 items, clustered around the three dimensions, customer relationship management (CRM), inventory management (IM) and order management (OM). The interviews were conducted in the back-offices of four German pharmacies to ensure a proper environment for an interview. Each interview lasted for around one hour and was done with the manager and two other employees, who are in charge of the OM, IM and CRM. All interviews were conducted in the same manner and line of inquiry (Yin, 2009). A transcript for each interview was developed, therefore allowing us to analyze and propose customer-oriented RFID solutions embedded within a conceptual approach for SC value creation. After four interviews, each representing one case study, saturation was reached, giving us the confidence in our results (Thiétart, 2001) as no additional critial enrichment of our data could be achieved (Yin, 2009). In the following, the obtained data is modeled using the e3value method (Pijpers, Gordijn, & Akkermans, 2009). This method was originally designed to assess the profitability of e-businesses; yet, it has proven to be particularly useful to illustrate value streams of both goods and services along different types of SC. As the flow of information is not originally included in the e3value method (Gordijn, 2002), we adapted and modified the method in order to present the material and information flows in our conceptual approach.

4 Results of the case studies

This section examines the four cases in detail in order to determine areas where the implementation of an RFID system may yield additional value. The focus is on the processes of order and delivery, on inventory management, as well as on the exchange of information between the pharmacies and the customers.

Due to confidentiality, the actual names of the pharmacies are altered and the pharmacies will be referred to as Pharmacy A, B, C and D in our discussion. Pharmacy A is located in a rural area in the Northern part of Germany, while Pharmacy B, C, and D are located in a Southern city of Germany. All pharmacies are privately owned and have a staff of ten to 15 employees.

4.1 Market analysis of German Pharmacies

The interviews showed that German pharmacies are situated in a strongly clustered market. The ownership structure is characterized by predominantly privately owned pharmacies. Over the last years, a new corporate ownership structure has been emerging and is continuously growing, with DocMorris, a franchise pharmacy, being a popular example (Gehmlich, 2008). Fueling the already harsh competition among the walk-in pharmacies is the presence of mail-order pharmacies. Furthermore, privately owned pharmacies are pooled in an association, the Apothekerverband, representing their interests. Nevertheless, there is no exchange of operational information between competing pharmacies.

4.2 Order Management

The range of goods offered by a pharmacy can be divided into two segments. Firstly, non-prescription medicine is ordered directly at the manufacturer or at a wholesaler several times a year, based on seasonal demand forecasts. The comparatively large order amounts and good predictability of demand on the one hand allow for order bundling between different pharmacies of one owner, but on the other hand result in increased inventory levels. Order bundling on a larger scale, is currently not practiced due to rivalry.

The ordering process for prescription drugs, representing the second segment, is characterized through low stock levels and short order intervals. These drugs are ordered only at the wholesaler. When a customer demands a certain drug, the pharmacist first checks the availability of the product in their own stock. According to Pharmacy A, in the majority of cases, customer demands can be satisfied through their basic stock, whose level is forecasted based on historic data, immediately. Pharmacy B and D, on the other hand, stated that stock-out situations occur regularly, even several times a week, but are compensated by quick deliveries, having very short lead times of about three hours. Nevertheless, customers might have to come twice, even if it is only some hours later, resulting in a lowered customer satisfaction and possible losses in revenue.

Furthermore, out-of-stock situations occur regularly with products that are demanded very rarely and have a highly unpredictable demand in all four pharmacies, resulting in an immediate re-order process. The delivery date is based on its availability at the wholesaler and is instantly available to the pharmacist, allowing them to forward that information directly to the customer. All pharmacies order three or more times a day, at least once in the morning, once in the afternoon and once in the evening. The morning and afternoon deliveries arrive with a delay of three hours, while the evening delivery arrives early the next morning. This results in low stock levels for prescription drugs, due to the high frequency ordering process with small order sizes. Additionally, the German health insurance companies stipulate which brands of medication their insurants are allowed to procure. The underlying contracts to these stipulations may change on short hand notice, making it difficult for the pharmacies to sell the medication of the previous contract, once a new contract has been closed.

According to Pharmacy B and C there is a small amount of companies in Germany who offer specialized information technology (IT) solutions, among which the pharmacies can choose independently. In addition to the management of the order process, these software solutions offer a broad variety of functions, ranging from controlling over providing a product database to CRM.

4.3 Customer Relationship Management

According to the pharmacies, keeping close track of customers, including the record keeping of their consumption of prescription drugs, is regularly done. While Pharmacy A and D compile the personalized consumption data of all of their customers, Pharmacy B and C only compile the data from those customers who are registered at the pharmacy. The sales data is obtained for each customer at every purchase by scanning the barcode of each drug package, unregistering from the inventory. Pharmacy A stated that they derive the consumption data of heavy users with the help of the package size and the frequency of intake to trigger new orders in advance and to calculate demand forecasts, even so, sometimes the demand is not accurate, deviating by (plus or minus) two days. Moreover, pharmacies have a loyalty card system in place, recording the client’s purchase behavior of drugs in type and quantity and storing this data in an internal database.

The transfer of customer relevant information, i.e., dosage, side-effects, suggestion of additional and alternative products, etc., occurs during the sales interaction between the pharmacist and the customer. Most information and related advices are given orally and only the most important aspects are written manually onto the drug packages.

4.4 Inventory Management

The inventory is managed by the IT system of the pharmacy. Every product delivered to the pharmacy is currently registered in the system manually via barcode scanning. During this process, all necessary information, i.e., expiry date is recorded. Expensive and some prescriptive drugs are stored in a special secured storage area, allowing a close monitoring and analysis of relevant data. A documented process flow allows only some employees the access to that special storage area, resulting in an extremely low level of shrinkage due to damage, theft or spoiled products. Extending the existing process flow solution, automation is also considered as an option (Green & Hughes, 2011). Non-prescriptive and prescriptive commodity drugs are stored within the sales area and can be accessed by customers and all pharmacists. According to Pharmacy A, this IM procedure yields a very accurate picture of the current inventory level. Especially concerning the monitoring of the expiry date, pharmacies have achieved a high level of precision. All pharmacies have implemented processes, which enable them to keep close track of the expiry date of their products. However, if a good is unsalable or is close to its expiry date, the pharmacies furthermore have the opportunity to send the drugs back to the supplier, getting a refund on the original price. This procedure is applied for both prescriptive and non-prescriptive drugs and is based on either the wholesalers or manufacturers goodwill or the terms of the delivery contract.

4.5 Conclusion for the case studies

The case studies have shown that pharmacies manage most of their operational routine quite efficiently. However, the *ordering process* for prescription as well as for non-prescription drugs is on the one hand characterized by a high degree of transparency and on the other hand dependent on customer information and the expertise of employees, leaving an opportunity for improvement. The forecasts for non-prescription drugs, its combination with high delivery frequencies, short lead times, and relatively exact delivery dates leave little room for improvement through RFID tracking. RFID technology could be still used to achieve process improvements within the pharmacy such as, enhancing automated controls for inventory.

In terms of *customer relationship management*, both pharmacies had strategies in place to increase customer value to some extent. Record keeping of customer's demand and purchasing habits enabled pharmacies to better understand customer's needs. The pharmacies can predict the intervals at which certain prescription medicine is requested. RFID is not considered essential for a further improvement of the customer relationship from pharmacies´ point of view, although significant amount of human expertise is needed in demand prediction and planning. Further, customer-specific information such as dosage, side-effects, etc. are only shared orally and not maintained and utilized in a systematic manner. Pharmacies believe that sharing more information with customers can result in them becoming more independent. This results in an apprehension of losing customer´s loyalty instead of making use of gathered information to improve the CRM.

Although *inventory management* of the analyzed pharmacies is currently done manually, it is accurate in most cases. This also implies very low failure rates of the inventory related processes. RFID might contribute to higher customer satisfaction due to fewer stock-outs, as customers do not have to come twice, as the product is available immediately.

Overall, the advantages of RFID for pharmacies in terms of optimizing operational efficiency and CRM can be considered marginal from the pharmacies point of view. The initiative to implement an RFID system therefore has to come from the manufacturers, distributors, and customers who have the most benefit of its implementation, as outlined in section two.

Furthermore, the interviews have shown that pharmacies have implemented IT solutions to facilitate their operational routine. Yet, none of these solutions can be considered as centralized in terms of enabling a continuous flow of information throughout the SC. In this sense, they only communicate with the adjacent tier. This situation is further worsened by the harsh competition among the pharmacies and the resulting unwillingness to share any information with their competitors.

One possible solution would be to implement a *central information system (CIS)*, enabling all SC members to share certain common information and in achieving complete transparency. Nonetheless, it is important, that the CIS enables competitive advantages while contributing to value creation as previously mentioned. Considering this issue, it is reasonable to have either the wholesaler or the manufacturer operating the CIS.

The e3value model depicted in **Figure 1** represents an exemplary pharmaceutical SC consisting of the members that were analyzed in the previous chapters. Furthermore, the flow of goods and information is depicted. The interviews have shown that the information that is currently exchanged in pharmaceutical SC is limited to delivery information and order information.

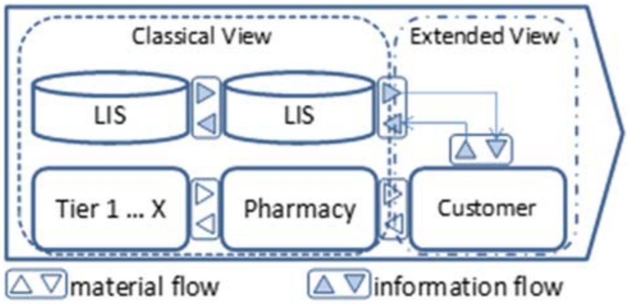

Figure 1 – Exemplary Pharmaceutical SC

The Classical View is characterized by the fact that the benefits of RFID end at the stage of the pharmacies. In case of a patient´s drug purchase, the RFID tag is deactivated and no additional value in the downstream SC can be achieved. In contrast to this approach, the Extended View extends the use of RFID tags beyond the point of sale (POS) allowing a higher value creation in the SC for all SC members including the customer. This customer-oriented extended view of RFID solution is described in the following section.

5 A conceptual approach for customer-oriented RFID solutions

Customers of pharmacies consist on one hand of the elderly, sick people with chronic diseases who need medication on a regular basis, and on the other hand of occasional drug users that are not accustomed to the regular use of pharmaceuticals. The use of medicine may take up a dominant role in the patient's life, especially in case of the elderly and the chronically sick, giving these consumers the biggest benefits from RFID service solutions.

In the majority of cases, the consumption of drugs is linked to a predefined schedule in order to ensure their effectiveness. The right dosage of medication is also a critical factor for the prevention of health risks and the recovery of a patient (de Castle et al., 2004), (Kaelber & Bates, 2007). Especially elderly people, who suffer from decreasing cognitive abilities, may not be able to remember the dosage of medication correctly. The basis for a correct intake of pharmaceuticals is the information, mainly orally, given to the clients. This information though, can be unclear to the patient and might be forgotten or lost. The broad varieties of pharmaceutical goods on the market that interfere with each other further complicate this situation for the consumer.

In order to solve the presented issue, we propose interactive non-stationary decentralized RFID services as solution (see **Figure 2**, dotted line), effectively applying IS in the downstream pharmaceutical SC (Chien et al., 2011) through usage of RFID tags attached to the drug package. Therefore, the customer needs a mobile device with a read/write-ability for RFID tags. We propose the utilization of smartphones, due to its increasing sales figures (Pettey & Goasduff, 2011), equipped with NFC and a specialized application (app) installed on them. The increasing availability of NFC smartphones amplifies customers' interest in mobile applications and technology (Lutherdt et al., 2009). Even so NFC is a new technology its usability for elderly and disabled persons has been positively tested (Häikiö et al., 2007), (Köbler, Koene, Leimeister, & Krcmar, 2011), (Prinz, Menschner, & Leimeister, 2012). To ensure the most benefit, NFC smartphones need the ability to exchange information, stored on the RFID tag, with the CIS, enabling an independent operation of the system and information exchange in case of Internet availability.

Implementing the presented approach (see Figure 2), allows us to bridge the existing issues between pharmacies, supported by local information systems (LIS), and to synchronize the information within the SC. Furthermore, the information stream is extended towards a bidirectional flow, providing the opportunity for interaction between customers and pharmacies. In consequence, pharmacies can use more detailed information from customers to apply real-time planning processes in their OM, realizing positive effects in the IM. Moreover, more accurate information also affects the CRM, avoiding stock-out situations, generating customer value. Additionally, depending on access to the internet, the solution can be used in both online and offline modes.

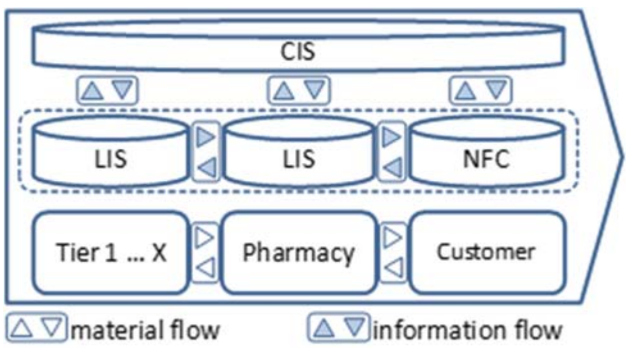

Figure 2 – Conceptual Approach

Examples for customer-oriented solutions are a digital leaflet, individual intake information and schedule, further relevant information, i.e., side-effects with other drugs, reports and experience from other customers and alternative or additional treatments. The approach to store individual information on RFID tags, could, i.e., prevent patients adding expired drugs to the actual ones, as they may interact badly. On the other side, in case the pharmacy knows the availability of certain drugs at the patient and its expiry date allows them to propose alternative medicine, therefore saving the customers´ money and increasing the trustworthiness of the system. Additionally, this information could be used to plan procurements instead of estimating and thereby increase the accuracy of the order process. Moreover, a digital leaflet used within a mobile application enhances users to zoom the instructions due to its focusing function. Another opportunity is the inclusion of social networks within an application, enhancing patients to share and present experiences and reports with other customers in an efficient manner. Further functionality could be a reminder function, which is linked to the pharmacies´ IS, allowing both sides to ensure the right dosage at the planned time. An extension of this functionality, would allow pharmacies to inform a patient about special offers, events or general news concerning pharmacies or the health care system. Many more customer-oriented solutions are possible, therefore creating value for the customer.

6 Conclusion and Implications

This paper assesses the implementation of RFID in the pharmaceutical SC from the German pharmacies' point of view with a multiple single-unit explorative case study approach, enhancing us to propose a conceptual approach contributing to higher value generation in SC. The multiple explorative case study approach revealed that, on the one hand, equipping drugs on item level with RFID tags can currently only yield marginal benefits for pharmacies, as their internal processes already operate at a high level of efficiency. However, our proposed approach enables all members of the SC to realize benefit by combining the strengths of centralized and decentralized approaches. Moreover, we propose to extend the use of RFID tags onward to the end customer on item level basis in order to improve the customer service, i.e. providing personalized consulting based on patients´ individual information. There is further potential for improving pharmacies OM, positively affecting the IM and CRM, avoidance of stock-out situations, and thereby increasing customer satisfaction.

Furthermore, the approach allows access to information through a mobile device, proposing various options to benefit from the bidirectional information flow between pharmacy and patient, i.e., providing information about the customer's consumption data. Overall, we propose a schematic concept, which is capable of achieving value for SC members using a decentral approach. Consequently, with a NFC smartphones as the functional unit of RFID-based services on the end customer's side, we propose that the spectrum of possible medicine-related applications, contributing, i.e., to process efficiency (Vinjumur, Becker, Ferdous, Galatas, & Makedon, 2010), increasing quality (Wu, Kuo, & Liu, 2005) and managerial benefits (Kolias et al., 2010), exists and needs to be considered to solve future challenges. Furthermore, we see NFC in the healthcare sector as innovative technology (S. Fosso Wamba, 2011), transforming processes and thereby creating value (Ngai, Poon, Suk, & Ng, 2009), (Oztekin, Pajouh, Delen, & Swim, 2010).

7 Limitations and Future Research

We presented a conceptual approach for RFID usage within pharmaceutical SC. Nevertheless, the investigation did not include several factors. First, customers were not interviewed; instead, we used deductive reasoning to elaborate the customer-oriented solution. Second, we ruled out security, privacy and implementation issues related to RFID and to the CIS, presenting evidence from literature. Third, we did not consider interoperability of different RFID standards, due to the awareness that this issue needs to be reflected for each RFID information system integration project (Engel, Goswami, & Krcmar, 2011), (Günthner & Fruth, 2011). Fourth, economical figures were not derived, instead our research focused on theoretical solutions, based on the RFID technology and the typical characteristics of a pharmaceutical SC.

Future research should include customers and examine their interest in our proposed approach. , This can be done by using prototypes to obtain more meaningful feedback, given the novelty of the NFC technology. Additionally, more specific and detailed insight into the pharmaceutical upstream SC, i.e., procurement, production and distribution processes, can enable researchers to propose more value generating configurations and approaches. Further, an implementation of the approach proposed in this paper, allows researchers to compare between central and decentral systems in a pharmaceutical SC, and gain insight into important and necessary information towards value creation.

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Publication 10

Investigating Information Sharing Behavior in Supply Chains: Evidences from an Embedded Single Case Study

Title	Investigating Information Sharing Behavior in Supply Chains: Evidences from an Embedded Single Case Study	
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Abstract

Significant differences exist in the exchange of information between supply chains members. Various factors such as bargaining power, trust, contracts, and information management capabilities of firms influence firms' information sharing behaviors. Based on an exploratory case study, we analyze and compare supply chains to identify different information sharing patterns, and the factors contributing towards these differences. We found that while information sharing leads to higher benefits for all supply chain members, the fear of losing bargaining power is more important for the stronger firm than achieving mutual performance gains. Further, internal structures and socio-political aspects prevent firms from continuous exchange of information. We propose guidelines outlining different information sharing behaviors in supply chains, and thereby contribute to theory by explaining the association and influence of different factors on firms' information sharing behavior. Practitioners can use the guidelines to improve supply chain performance by formulating appropriate information sharing strategies.

Individual contribution from Tobias Engel: For this paper, I contributed by writing all chapters with my co-authors. Further, we developed the interview questions and the coding scheme. Moreover, I attended all interviews, analyzed, and discussed the results. The review comments were addressed by me, and I was in charge to submit the new version of the paper.

1 Introduction

Information sharing is a key supply chain management initiative to realize higher performance gains within supply chains and networks (Klein & Rai, 2009). Existing research suggests a positive contribution of information sharing towards supply chain performance (Rai, Patnayakuni, & Seth, 2006). While strategic information sharing is particularly beneficial for supply chain performance, 90% of firms share only transactional information, (Prokesch, 2010). As a result, firms struggle with problems such as high inventories and product markdowns (Clark & Lee, 2000). Despite the identified benefits of sharing information within the supply chain, many firms avoid information sharing with their suppliers and buyers (H. L. Lee, Padmanabhan, & Whang, 1997).

Possible explanations for the reluctance to share information include the aim for selfish enhancements of competencies resulting in competitive advantages and bargaining power within a relationship (Nair, Narasimhan, & Bendoly, 2011). Furthermore, access to and control over strategic information enables firms to influence terms and conditions in their own favor (Argyres & Liebeskind, 1999). This results in widely varying supply chain strategies in terms of information sharing among supply chain members with different power relationships (Gérard P. Cachon & Lariviere, 2001; Patnayakuni, Rai, & Seth, 2006). For example, the influence of bargaining power on information sharing is evident in the case of Dell who uses its strong bargaining power position to integrate upstream supply chain partners into its information flows and material flows as well as applying information sharing routines, resulting in a negative cash-conversion cycle of five days and other process improvements (Magretta, 1998).

Information management capabilities of firms such as supply chain knowledge, and socio-political factors such as trust and contracts have been identified as influence factors on information sharing in previous studies (Patnayakuni et al., 2006). However, the inter-relation of these factors, their effect on information sharing and supply chain initiatives in practice is not clear (Emberson & Storey, 2006; Ketchen & Hult, 2007).

Further, previous research mainly focuses on analyzing the influence factors on information sharing in primary supply chains, while in support supply chains differences in information sharing behavior have been scarcely examined. Primary supply chains focus on the supply of direct material for the production of goods, whereas support supply chains deliver products and services indirectly enabling production processes (Nissen & Sengupta, 2006). For example, the supply of food and beverages for planes allows firms to provide passengers with service, while the flight itself can be considered as the primary value for customers and therefore represents the core activity of the firm. Further examples can be found in all supply chains providing firms with maintenance, repair and operations (MRO) goods such as oil for machines or office supplies for employees (Nissen & Sengupta, 2006).

Support supply chains play an important role to ensure the operability of organizations, and provide critical support to the primary or production supply chains, and contribute towards efficiency and effectiveness of firms (Donnelly, 2013; Puschmann & Alt, 2005). Firms incur significant cost in procuring various resources which form a part of the core infrastructure of the firm or support their core operations in various ways (such as information technology hardware and software), and accordingly the supply chains for procuring such support resources need to be proactively managed to ensure efficiency of business operations. However, support supply chains are usually not considered as strategic by most firms. Therefore, concerns regarding opportunism and/or loss of bargaining power may influence firms' behaviors in these supply chains differently.

We analyze the information sharing processes of support supply chains in order to improve their efficiency and effectiveness. This allows us to derive guidelines to effectively manage and govern information sharing processes for more efficient utilization of resources.

The rest of the paper is organized as follows. In section 2, we provide the theoretical background by describing the factors that can influence information sharing behaviors in the field of supply chain management. Our research methodology is described in section 3. Section 4 presents the result of the case study, followed by a discussion of the findings and implications of our research. Finally, we present the limitations, further research possibilities and draw a conclusion.

2 Theoretical development

This section describes the influencing factors and variables, which affect information sharing in supply chains. We draw from transaction cost economics (TCE), relational exchange theory (RET) and from the resource based view (RBV) to explain the role of contracts, bargaining power, trust, and information management capabilities. While TCE allows us to postulate the relationship between contracts and bargaining power, we draw from RET to incorporate trust as a relational construct. The RBV contributes by emphasizing the significance of information management capabilities. This offers a unique perspective on information sharing in supply chains, allowing us to analyze the information sharing process, and factors that trigger information sharing.

In the course of the embedded case study, relationships within the various supply chains are differentiated based on the bargaining power distribution of strong/weak partners as well as based on whether the respective firms are dependent on the cooperation as opposed to easily interchangeable relationships. The influence of bargaining power, contracts, and supply chain partnerships on information sharing has been analyzed (S. Mithas & Lucas, 2010; Williamson, 1989). The distribution of bargaining power and inter-relational dependencies among supply chain members allows to study situations such as supply chain specific investments (Nair et al., 2011), the behavior in supply chains with exit options (Phelan, Arend, & Seale, 2005) and decentralized supply chains (Berstein & Federgruen, 2005). Further, in case of long-term relationships, commitment and flexibility in agreements play an important role (Gérard P. Cachon & Lariviere, 2005), attracting partners to share information to participate in performance-enhancing investments (Liker & Wu, 2000).

Accordingly, we review trust, bargaining power, contracts and information management capabilities to analyze their effect on information sharing behaviors.

2.1 Information sharing

Transactional information sharing is a necessary step in the process of exchanging goods within supply chains. Supply chain partners are able to improve efficiency regarding supply chain procedures and actions using operational information sharing (Seidmann & Sundararajan, 1997). Operational and strategic information sharing enable further improvements of overall supply chain performance and rent creation (Klein & Rai, 2009). In order to create additional economic rents, firms need to ensure the accuracy and relevance of shared information. Furthermore, supply chain partners need to have the capabilities to formulate and execute necessary actions for improving supply chain performance by using the additional information (Goswami, Ravichandran, Teo, & Krcmar, 2012; Wang & Wei, 2007).

However, firms may have strategic reasons to avoid information sharing with supply chain partners. Strategic considerations may outweigh the potential for higher profits and prevent firms from mutually sharing information (H. L. Lee et al., 1997). Furthermore, firms may decide against information sharing in order to avoid the risk of partners unilaterally using information asymmetries as a competitive advantage increasing their individual rent. This reluctant behavior is frequently observed in more opportunistic as well as purely transactional relationships (Argyres & Liebeskind, 1999; Nair et al., 2011). Information asymmetries or knowledge asymmetries result in lower supply chain performance (Narayanan & Raman, 2004). Isolated behavior of firms in a supply chain or network often leads to a tit-for-tat strategy causing lower rent (Axelrod, 1984). Firms often set up schedules for information sharing (Fangruo, 1999), and contractual safeguards to counter such behavior and avoid operational inefficiencies (Mason-Jones & Towill, 1997).

2.2 Bargaining power

Bargaining power describes the ability of one party to exert influence over another party. The bargaining power position of a firm in a supply chain is defined by the product and the holistic bargaining power position of the firm in the industry (Porter & Millar, 1985). Bargaining power has been analyzed in various supply chain settings using different perspectives such as information sharing, incentive alignment and power-relational aspects (G. P. Cachon & Fisher, 2000; Nair et al., 2011). From an information sharing perspective, the form of power – reward power, coercive power, expert power, referent power and legitimate power – over information needs to be considered, as it influences aspects such as punishment or reward in supply relationships (French & Raven, 1959; Maloni & Benton, 2000).

Previous research suggests that firms use their bargaining power position in order to improve supply chain performance by introducing new supply chain management systems (Subramani, 2004). Further research has analyzed the influence of investments on bargaining power and inter-firm relationships (Nair et al., 2011). Additionally, power relations within supply chains and their influence on revenue sharing processes have been studied (Gérard P. Cachon & Lariviere, 2005).

Firms prevent information sharing in case of changing power relations within the supply chain, especially in the absence of trustworthy supply chain relationships (Stanley E. Fawcett, Ogden, Magnan, & Cooper, 2006). Therefore, information as a source of power within firms and among partners is often tightly controlled. Moreover, the use of coercive power harms information sharing among supply chain members (Maloni & Benton, 2000).

From a bargaining power perspective, access and control over strategic information may allow firms to influence conditions in their own favor (Argyres & Liebeskind, 1999), while operational and strategic information sharing can lead to a less beneficial situation for the stronger firm in case of opportunistic behavior from his partner (Axelrod, 1984; Parkhe, 1993). Contracts can be used to safeguard against shifts in bargaining power, to minimize opportunistic behavior and to ensure mutual information sharing (Seidmann & Sundararajan, 1997).

2.3 Contracts

The aim of a contract is to guide the behavior of partners towards desired objectives (Goo, Kishore, Rao, & Nam, 2009). Contracts govern the ratio between profits and risks in supply chain relationships (Lacity & Willcocks, 1998).

Existing research has investigated how contracts influence information sharing and improve information sharing processes such as forecasts or inventories (Gérard P. Cachon & Lariviere, 2001). Furthermore, the usefulness of contractual safeguards for inventory policies to minimize supply chain costs have been examined (Gérard P. Cachon & Zipkin, 1999).

Formal and informal contracts are used to create a safe relational basis for two or more firms (Poppo & Zenger, 2002). A contract can be used to enforce a reward or penalty system acting as an incentive for collaboration among supply chain members. Accordingly, a contract acts as a safeguard for supply chain specific investments (Gérard P. Cachon & Lariviere, 2005; Williamson, 1979, 1989). Further, contracts ensure cooperative behavior, lower the risk of a loss of strategic information and suffering from opportunistic behavior from the partner (either supplier or buyer) (Klein & Rai, 2009). Even when partnering firms agree on responsibilities and information flows, firms may insist on signing a contract to minimize opportunistic behavior (Ghosh & Fedorowicz, 2008). Therefore, contracts can be seen as a complement and/or substitute for trust in case of missing predictability of a partner’s behavior.

2.4 Trust

Trust is defined as “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trust or, irrespective of the ability to monitor or control that other party” (Mayer, Davis, & Schoorman, 1995). Trust can be described as the adhesive, informal, and flexible connection between socio-political aspects and political behaviors. Therefore, trust is an important factor that can influence the success of supply chain collaborations and represents the social facet in supply chain relationships (Shub & Stonebraker, 2009; Whipple & Frankel, 2000). Furthermore, shared norms and common values impact relational aspects in supply chains more than strict and explicit formal contracts (Dyer & Singh, 1998). However, missing long-term orientation and the lack of trust contradict information sharing. Trust-based relationships trigger incentive alignment whereas cultural factors facilitate the formation of trust and therefore influence the extent of incentive alignment (Griffith, Myers, & Harvey, 2006). The trust building process is affected by five factors: calculation, prediction, intentionality, capability, and transference (Patricia M Doney, Cannon, & Mullen, 1998).

In the context of supply chain relationships, trust is based on fair behavior among supply chain members and a sense of reciprocity, although this does not entail that (economic) outcomes will be equally divided between supply chain members (Hart & Saunders, 1997). The importance of trust for supply chain collaborations grows as the number of supply chain members increases. This is especially true in cases where decisions have to be made with incomplete information (Komiak & Benbasat, 2004). According to Giguere and Householder (2012), the information sharing level is more dependent on trust than on information management capabilities of firms.

Trust strengthens supply chain relationships, motivates firms to invest idiosyncratically into long-term relationships (P.M. Doney & Cannon, 1997), reduces uncertainty and risks (Alvarez, Barney, & Douglas, 2003), fosters satisfactions (Zaheer, McEvily, & Perrone, 1998) and encourages operational and strategic information sharing (Stanley E. Fawcett et al., 2006). Further, trust reduces the complexity of supply chain relationships by eliminating dispensable processes, such as the justification of decisions (Kramer, 1999). Moreover, shared values such as sharing common goals, behaviors, and policies characterize trust based supply chains and determine involvement in joint decision making towards mutual commercial goals (Dwyer & Oh, 1988). In case of differences in bargaining power and/or asymmetric information among the supply chain members, trust is crucial to reduce the uncertainty and enable mutual information sharing in supply chain relationships (Agarwal, Shankar, & Tiwari, 2007).

2.5 Information management capabilities

Information sharing is influenced by information management capabilities. These can be considered a higher order capability that is made up of technical as well as supply chain knowledge capabilities (Sunil Mithas, Ramasubbu, & Sambamurthy, 2011; Rai et al., 2006).

Technical skills are a precondition for information sharing, since it ensures aspects such as data quality, linkage of information systems, and therefore can be seen as base for (electronic) sharing of information (S. Mithas & Lucas, 2010, p. 5; Rai et al., 2006). Further, technical capabilities include the usage of appropriate information technology (Bharadwaj, 2000) such as the implementation of EDI across the supply chain (Bailey & Francis, 2008). However, information technology and technical capabilities are necessary but not sufficient requirements for information sharing across supply chains (Stanley E Fawcett, Osterhaus, Magnan, Brau, & McCarter, 2007). Supply chain knowledge complements the technical capabilities of firms and positively influences supply chain processes such as collaborative planning by identifying relevant, timely, and accurate information, and supply chain performance (Goswami et al., 2012). Further, the knowledge of supply chain processes and their impacts increases the level of shared information leading to positive effects on supply chain performance (Hult, Ketchen Jr, & Slater, 2004). More specifically, supply chain knowledge enables firms to recognize relevant information and use the information to improve information sharing processes (Wang & Wei, 2007).

Hence, we explore the influence of information management capabilities on information sharing in our case study.

3 Research Methodology

As unit of analysis, we chose an IT hardware supply chain to explore differences in information sharing behavior among supply chain partners using an embedded single case study approach (A. S. Lee & Baskerville, 2003; Yin, 2009). These supply chains can be classified as support supply chains as they do not form a part of the core business for the customer, while the supply chains are important for the upstream partners. However, these support supply chains also need to be monitored carefully as they have significant effect on the overall cost efficiency of organizational operations. The supply chains were chosen due to their low demand uncertainties. Under such stable conditions supply chain strategies focus towards enhancing efficiency in order to provide the product to the customer at the lowest costs (H. L. Lee, 2002).

In accordance with the guidelines from Myers and Newman (Myers & Newman, 2007), we developed a semi-structured interview guideline from literature covering the reviewed influence factors and executed a pre-check with two supply chain experts and two independent researchers. This process ensured construct validity, ordered questions and an extensive coverage of the topic (Yin, 2009).

Based on our network, we identified one major manufacturer within the aircraft industry (also referred to as customer and/or buyer), experiencing inefficiencies in the support supply chain (IT hardware). This allowed us to interview service providers, retailer, wholesaler, and IT hardware manufacturers in four different supply chains. Four supply chains were chosen by the responsible manager from the buyer due to expected improvement potentials.

For the analysis of these four supply chains, thirteen persons from eight different firms were interviewed. The interviewed employees are responsible for sales, purchasing, logistics, and general management. The interviews were conducted in person and took place during March and April 2013 in Germany. Interviews lasted 45 minutes on average. Notes were taken during the interviews, since audio recording was not allowed. In addition, we reviewed internal documents about the material flows and information flows. There were no contradictions of statements, therefore giving us confidence in our results. The described process allowed us to reach saturation, as no additional critical enrichment of our data could be achieved (Eisenhardt, 1989; Yin, 2009).

To code the interviews and case material, we derived a coding scheme from reviewed literature. The interviews were independently coded and analyzed by three researchers. Rival explanations were resolved in group discussions among the authors (Krippendorff, 2012; A. S. Lee & Baskerville, 2003; Yin, 2009). By following this process, we were able to comply with the quality criteria for case studies suggested by Yin (2009). Due to the high level of validity and reliability, we are able to generalize from an empirical description towards guidelines for information sharing in support supply chains (Eisenhardt, 1989; A. S. Lee & Baskerville, 2003; Yin, 2009).

4 Results of the case studies

In this section, we describe four supply chains in order to analyze the upstream supply chain for hardware IT equipment from a customer's perspective. The customer is a major supplier in the aircraft industry. The similar structure of the supply chains allows us to analyze and compare the results regarding the influence of information management capabilities, contracts, bargaining power, and trust on information sharing.

The first and second supply chains cover the buying process of phones and computers, while the third and fourth supply chains cover the buying process of printers and projectors. Supply chain partners who are involved in all supply chains are the IT buyer of the customer from the IT department and a general buyer from the purchasing department. However, the upstream supply chain partners vary. In the first and second supply chain, there is one upstream partner, who provides services to the customer, and acts as retailer and wholesaler. In contrast, in the third supply chain, we have one service provider offering additional services and one wholesaler supplying the products. The fourth supply chain integrates an independent retailer as an additional supply chain partner. The manufacturers are always different firms and focus on their products. Therefore, the responsibilities and roles of firms vary among the analyzed supply chains (see Figure 1). More specifically, the IT Buyer is responsible for ordering devices, while the general IT buyer negotiates yearly contracts and deals with general concerns. Service providers are responsible for additional services such as temporary storage tasks, testing, and setup of products. Retailers and wholesalers further distribute the products along the supply chain while manufacturers produce the demanded IT equipment including phones, computers, printers, and projectors. In case of the first and second supply chain, all tasks except the manufacturing process are affiliated in one firm. In the third supply chain, the retail function has been eliminated, whereas all functions are separated into four independent firms in the fourth supply chain.

While the customer and the manufacturers belong to the top ten firms in their respective fields and operate globally, the wholesalers are mid-sized firms operating on a European level and the service providers are small regional firms.

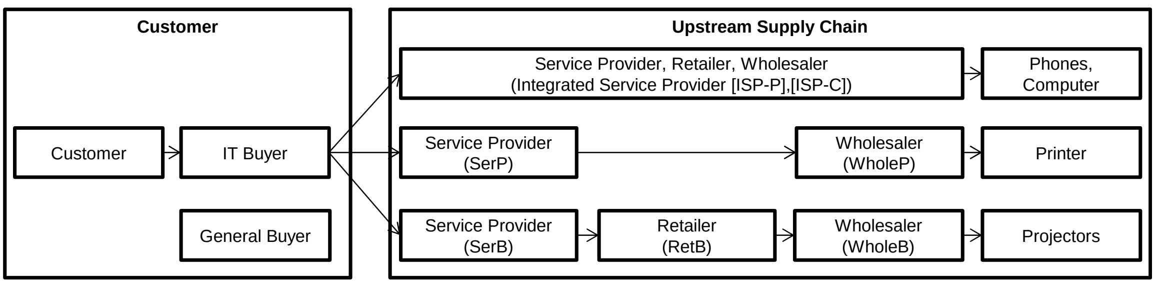

Figure 1 – Support Supply Chain

4.1 Information management capabilities

The information sharing process varies between the supply chain members. Information systems are not linked to each other resulting in many media disruptions in the information flow. Moreover, the supply chain processes are very complex and are only partially known by each supply chain partner resulting in longer cycle times. Further, an accurate overview of material and information flows does not exist. This results in the usage of many different solutions such as network drives, E-Mail, fax, and EDI to transfer order related information. Although all supply chain partners agreed on mutual solutions, they prefer to use E-Mail for orders. From an operational information sharing perspective, only forecast figures are shared on a half-yearly basis in personal meetings. However, this does not allow the upstream supply chain partners to make use of that information, as it can be seen only as an indication and cannot be used for daily planning processes. For example, the printer manufacturer would expect more regular forecasts and longer lead times since accurate and relevant forecasts are identified by the printer manufacturer as a key success factor towards realizing customer satisfaction and on-time deliveries *("Precise and timely information is important … Monthly forecasts and three months lead time would be good" [Printer Manufacturer])*. However, within the supply chains, there is no sharing of operational or strategic information such as inventory levels due to limited interest in improving processes. *("… I don't think outside the box. I am interested in my supply chain until WholeP, what the others do does not interest me…" [Customer])*. The lack of system integration results in very long delivery times for some products. For example, projectors are supplied within a range of three to four weeks after the initial order from the customer. Despite that, some supply chain members such as WholeP made efforts to link systems and improve information sharing processes. However, due to a weak bargaining power position, no improvements have been realized. Further, the reluctance regarding system integration suggests a lack of supply chain knowledge capabilities among the majority of the supply chain partners, especially as most employees were not able to identify relevant information *("I have no idea how we could use information to improve the supply chain" [ISP-P])*.

4.2 Contracts and bargaining power

In the analyzed supply chains, the customer and the manufacturers have equally strong bargaining power positions while the retailers and service providers are in weak bargaining power positions *("RetB has to do what we want." [Customer])*. Formal contracts are generally identified as a prerequisite for collaboration *("Can you imagine a relationship without contracts? I would not do that." [Customer])*. Therefore, several supply chain partners have established formal contracts incorporating service level agreements to ensure required services such as delivery time.

From a manufacturer's perspective bargaining power and the importance of the final customer influence the supply of goods, resulting in clustering the customers according to the ABC-analysis *("Orders are processed according to ABC customers" [Printer Manufacturer])*. Furthermore, there is a discrepancy between the perceived bargaining power of supply chain partners and the actual power distribution in some cases. More specifically, lack of transparency in information flows seems to result in a wrong perception of the bargaining power position of upstream supply chain partners. For example, SerP perceives himself in a strong bargaining power position, while the customer considers SerP solely relevant in order to deliver services *(“We are in a good [bargaining power] position as many processes are deeply interconnected. Further, we have a good long-lasting partnership.” [SerP])*. However, the service providers are aware of the general bargaining power position of firms in the supply chain, mainly due to long-time knowledge of the partners *("…we are the service provider. We cannot define our expectations towards the buyer." [SerP])*.

4.3 Trust

The relationships within the analyzed supply chains are historically grown. The long-term relationships have led to trustful relationships in terms of daily business operations, while trust on a strategic level has not been established. Firms limit information sharing onto a transactional level as they fear opportunistic behavior – usage of coercive power – of their partners on a strategic level *(“…if you share (strategic) information, they (the suppliers) will increase the price by ten percent and give a rebate of 15% in the end …” [General Buyer])*. This may negatively influence price negotiations or process improvements resulting in lower value for all supply chain members.

Despite that, the supply chain collaboration is based on common values such as loyalty, fairness and a frequent open communication. Trust is an important factor for the success of the supply chain according to RetB, WholeP and the computer manufacturer *(“not being pulled over the barrel… openly discuss mistakes” [WholeP])*. Furthermore, all supply chain members state that they would collaborate in case of mutual gains. However, common goals are only discussed orally, lacking a follow-up processes such as documentation and controlling. Further, we found that for the customer, performance is more important than trust, which is manifested in the customer’s willingness to change upstream supply chain partners in case of a decreasing performance.

5 Discussion & Implications

Previous research results indicate that supply chains with a low demand uncertainty and a low supply uncertainty allow firms to create highest cost efficiencies by sharing demand, inventory, and capacity information (H. L. Lee, 2002). We examine information sharing in such support supply chains, and explain barriers and influence factors on information sharing. Therefore, we propose guidelines to derive strategies towards realizing expected cost efficiencies by managing and governing information sharing among supply chain members. Further, we discuss how these factors are inter-related among each other.

Our analysis shows that the technical information management capabilities of analyzed firms in the supply chains are on a low level due to missing linkages between systems and the usage of E-Mail, Fax, and Phone for orders on a daily base. Furthermore, partners share only transactional information, while some operational and strategic information is shared orally. Both aspects indicate missing technical information management capabilities of firms and little awareness of possible information sharing contributions to supply chain performance (Bailey & Francis, 2008; Bharadwaj, 2000). Moreover, we found that information sharing processes are not well documented throughout the supply chains which increases the barriers to switch partners and negatively impacts possibilities to improve information sharing processes. This behavior reflects the fear of firms to lose bargaining power by sharing information (Stanley E. Fawcett et al., 2006).

Forecast information is shared on a half yearly base limiting its accuracy and usefulness. This might be due to negative experiences with upstream partners in the past and this seems to influence the internal behavior within the customers' organization, resulting in limitations on information sharing to a transactional level. This behavior can be interpreted as tit-for-tat strategy (Axelrod, 1984) and, in this case, it eliminates the possibility to improve mutually supply chain performance (Emberson & Storey, 2006). Furthermore, the customer defines a basket of goods with its manufacturers on a yearly base, while there is no willingness from the customers' side to make that basket electronically available. Although some of the upstream partners are aware that information sharing affects supply chain performance by e.g. using accurate forecasts to supply requested products in time, the customer perceives that sharing forecast information lowers their bargaining power position and suppliers would make use of it in price negotiations (Stanley E. Fawcett et al., 2006). The fear to lose bargaining power reflects reality to some extent, as the manufacturers and wholesalers cluster their customers as A, B or C customers affecting deliveries in case of bottlenecks. This finding describes how firms use coercive power to realize unilateral gains in the presence of formal contracts.

Although suppliers request more information, we found missing information management capabilities at the suppliers' side to e.g. define minimum inventory levels, and resistance of employees to acquire new supply chain knowledge manifested in their disinterest to support process changes such as the implementation of warehouse systems. This behavior reflects a lack of supply chain knowledge, while the disinterest can be interpreted as egoistical behavior or missing supply chain knowledge at the management level of the firms in the supply chain.

We found a similar level of supply chain knowledge at the customer's side even though the firm is aware that limiting information sharing to a transactional level increases the lead times and increases the need for inventories to fulfill their demands. Easy and useful solutions such as electronic catalogue systems were not considered as solution to reduce transaction costs, speed up cycle times, minimize deliveries towards the real needs, and at the same time keep supply costs at the same level. We assume missing leadership as problems, because employees from the customer tried to implement process improvements, while it has been ignored by the management level.

Furthermore, the firms do not agree on common goals and anticipate their bargaining power position differently. All firms state that they are open-minded for new ideas to improve information sharing processes. This statement, however, contradicts our findings, which indicate a lack of trust from the customer towards its suppliers, and e.g. a negative impact on forecast information sharing processes.

The described discrepancies in the information sharing processes reflect the influence of the analyzed factors on information sharing as the customer cares only about its direct upstream partners, while wholesalers and manufacturers would appreciate direct information flow from the customer (Gérard P. Cachon & Lariviere, 2005; Gérard P. Cachon & Zipkin, 1999).

Furthermore, historically grown organizational structures, personal relationships and internal promoters reject and avoid incremental changes (Zaheer et al., 1998). For example, the internal supply chain of the customer involves four departments with conflicting objectives such as best price vs. best service. As a consequence, the process itself is affected by political interests and conflicts between managers within the customer's organization.

In general, bargaining power was found to be the most important aspect from a customer's perspective. Therefore, the customer has built up complex supply chain structures to be in a better bargaining power position. This resulted in suppliers and service providers with low bargaining power, while wholesalers and manufacturers are in a better or at least similar bargaining power positions. This results in better service for the customer, as the customer is important for the service providers and suppliers, while processes are longer and prices are higher.

Our findings also indicate the higher importance of bargaining power compared to trust and contracts within efficient support supply chains. We found that trust is supportive for the business relationships and creates an open and friendly communication environment, resulting in higher flexibility, e.g. in case an employee asks for an exception. However, it was mentioned that no information would be shared without a Non-Disclosure Agreement and that formal contracts are mandatory. Further, we found that from a commercial and economic perspective, trust is not relevant for support supply chains and closer trustful relationships yield no additional advantage. A more distanced relationship allows buyers to be objective and negotiate better prices. Additionally, this supports compliance rules of companies in order to prevent corruption. However, as long-term relationships and trust positively contribute to mutual information sharing, the existence of compliance rules contradict information sharing to a certain extent. This explains the importance of a supply chain organization covering and adjusting the conflicting goals between logistics, purchasing and production.

Our results provide evidence for the complex inter-relations and influence of socio-political factors on information sharing in supply chains: The usage of formal contracts to define and avoid opportunistic behavior of partners, practiced forms of coercive power to punish the partner with higher prices based on shared information, and the existence of calculative trust are based on purely economic decisions.

Firms should consider a drop in their bargaining power to improve overall process efficiencies such as a positive effect on transaction costs or inventories. However, this leads to changes in the supplier structure. In case of changing the supply chain structure, the customer needs to consider costs and resistance of employees and firms.

Our findings imply that supply chain knowledge, bargaining power, and information management capabilities affect the implementation of supply chain information systems, its usage and especially the level of shared information within efficient supply chains, while trust and contracts have a minor influence on information sharing processes.

Table 1 depicts practical guidelines derived from our findings. The guidelines can help to set different information sharing criteria towards effectively managing support supply chains.

Guidelines for effectively managing support supply chains	
Bargaining Power and Trust	From a collaborative perspective, trust is more important than bargaining power to achieve mutual information sharing and process improvements.
Bargaining Power and Contracts	From a firm's perspective, bargaining power is more important than defining information sharing processes in contracts.
Bargaining Power and Leadership	Conflicting goals between departments/firms have to be balanced by a hierarchically higher supply chain organization/department.
Information Management Capabilities	Supply chain knowledge is important to share effectively and efficiently information among supply chain partners (and within the firm).
Trust	Irrespective of supply chain strategies, a collaborative approach is mandatory for mutual information sharing.
Corporate Compliance	Corporate compliance programs need to be balanced between enabling strategic information sharing and prevention of corruption.

Table 1 – Findings and Guidelines

6 Limitations and Future Research

The contribution of this paper should be interpreted in the face of its limitations. First, the findings from this study should be extended with caution to other industries, as explorative case studies do not allow researchers to control dynamic events and might capture only contemporary events (Yin, 2009). Therefore, an exploration of supply chains in other industries could validate and fine-tune the guidelines. Second, we found that bargaining power has a high importance even in support supply chains. It could be an interesting direction for future studies to explore if bargaining power has the same impact on information sharing for all supply chain categories (H. L. Lee, 2002; Nair et al., 2011). Finally, our research implies that supply chain collaboration is affected by different influence factors and information sharing alone is not sufficient. While there is significant research examining these factors in primary supply chains, there is less understanding regarding how these factors interact and influence support supply chains. Therefore, supply chain research should focus on the definition of the influence factors and the inter-relations of the factors affecting supply chain collaboration. Further, empirical studies should investigate other factors that have been outlined in TCE, RET and RBV and their influence on information sharing in supply chains. This will allow researchers to provide practitioners with strategies for managing and governing supply chains in a collaborative setting.

7 Conclusion

This research analyzed differences in information sharing among supply chain members and identified influence factors on information sharing. The analysis showed the importance of supply chain knowledge and bargaining power within support supply chain settings. Therefore, the results of this research allow firms to understand differences in information sharing behavior from supply chain members, and to develop actionable strategies and guidelines for managing, governing, and improving information sharing more efficiently. Our research contributes to theory by exploring the inter-relations of influence factors on information sharing behavior among firms in supply exchanges. We contribute towards a better understanding why 90% of firms still limit their information sharing onto a transactional level in supply chains (Prokesch, 2010).

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