Information Sharing in Multi-Tier Supply Chains - Moving Beyond the Dyads

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Information sharing in multi-tier supply chains

Moving beyond the dyads

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To Alexandra, Filippa and Elliot

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May 2015, Lund

Joakim

Abstract

As international competition increased towards the end of last century, companies realized the importance of collaborating and sharing information with suppliers and customers to remain competitive. By sharing information such as forecasts of future demand with partners in the supply chain, it was possible to lower inventory holding costs and increase the service level to customers, and thereby increase the competitiveness of the involved companies.

Previous research has proposed several benefits related to information sharing in supply chains. Suggested benefits include, for instance, better planning and scheduling of production lines, improved allocation and utilization of resources for transportation and warehousing, and reduced inventory levels and tied-up capital. However, it appears that few companies have been able to implement and benefit from information sharing. Several researchers conclude that information sharing in the supply chain is limited. Particularly, it seems as if companies have not been able to benefit from sharing information across multiple tiers in the supply chain. The lack of information sharing across multiple tiers is a challenge which is important to address considering that companies continue to struggle with problems related to the, so called, bullwhip effect. A supply chain which suffers from the bullwhip effect can experience distorted demand information as it is shared upstream in the chain. Such variations in demand information can lead to incorrect production planning and thereby alternately high inventory levels and increased costs for overtime and rush orders.

Against this background, several questions arise: For what reasons do companies refrain from sharing information across multiple tiers despite the fact that literature suggest that it is beneficial? Further, are there any companies that have implemented information sharing across multiple tiers and, if so, what are the documented benefits? Searching the answers to these questions reveals a gap in literature in that the majority of previous research studies have focused on dyadic relationship (i.e. supplier-buyer) instead of multi-tier supply chains (e.g. supplier-manufacturer-customer). The purpose with this dissertation is therefore to move beyond the dyads and explore information sharing in the supply chain, and investigate opportunities and challenges involved with sharing information across multiple tiers. The purpose is addressed in three separate but connected studies. Following a pilot study, a systematic literature review is

conducted to establish current knowledge in the research area. Thereafter, two empirical studies are conducted: a case study which maps an entire supply chain where data is collected from multiple tiers; and a Delphi study including a panel of experts who share their insights through multiple questionnaires.

The findings indicate that companies, for different reasons, refrain from sharing information across multiple supply chain tiers. One reason is the many challenges involved with implementing information sharing across multiple supply chain tiers. The major challenges include lack of trust between companies; lack of information quality; difficulties to share risks and benefits; lack of business processes; and the lack of a dominant player who can initiate change in the supply chain. Many companies are also preoccupied with internal issues and lack the ability to engage in information sharing across the supply chain. Another reason, from the perspective of contingency theory, seems to be that information sharing across multiple tiers is only beneficial in few, particular contexts. Such contexts relate to planned changes in the supply chain, for example in relation to new product introductions when future demand is uncertain. Findings also suggest a negative inter-relation between important and feasible contexts. In other words, in cases where it is possible to implement information sharing it is perceived to be less valuable and in cases where it is more valuable it is more difficult to implement. The findings further suggest that companies focus their information sharing with supply chain partners that represent high intensity of interdependence. Interdependence theory can thus help to explain why companies mostly share information with dyadic, strategic partners where the partners represent a large percentage of each other's portfolio and turnover. Moving beyond the dyads, the intensity of interdependence is reduced as firms are embedded in many networks and often have multiple suppliers and customers. The willingness to engage in multi-tier information sharing is therefore reduced.

This dissertation, which is one of the first to study information sharing in the extended supply chain, indicates that information sharing across multiple tiers is a rare phenomenon in industry. The dissertation also points out that several aspects must be considered to be able to implement and benefit from information sharing across multiple tiers. One of the contributions of the dissertation is a conceptual framework which can be used to guide future research and also function as decision support for companies to address and implement multi-tier information sharing.

Sammanfattning

I takt med ökad internationell konkurrens insåg företag mot slutet av 1900-talet vikten av att samarbeta med leverantörer och kunder för att hävda sig på marknaden. Genom att dela information såsom prognoser om framtida efterfrågan med andra företag i försörjningskedjan var det möjligt att minska lagerkostnader och öka servicegraden till kunder, och därigenom öka konkurrenskraften för de involverade företagen.

Litteraturen föreslår många fördelar med att dela information inom försörjningskedjan. Till exempel kan informationsdelning vara viktig för att bättre planera och schemalägga produktionslinjer, förbättra allokering och användning av resurser för transport och lager samt minska lagernivåer och bundet kapital. Det verkar dock som att få företag har lyckats dra nytta av fördelarna med informationsdelning. Flera forskare konstaterar att informationsdelning inom försörjningskedjan är begränsad; framförallt verkar det som att få företag lyckats dra nytta av att dela information över flera led i försörjningskedjan. Bristen på informationsdelning över flera led i försörjningskedjan är en utmaning och viktig att adressera eftersom företag fortfarande brottas med problem relaterat till den så kallade bullwhip-effekten. En försörjningskedja som drabbas av bullwhip-effekten kan uppleva förvrängd efterfrågeinformation då denna delas bakåt i kedjan – precis som en oxpiska. Sådana variationer i efterfrågan kan ge upphov till felaktiga prognoser, osäker produktionsplanering och därigenom växelvis onödigt höga lagernivåer och stora kostnader för övertid och akuta leveranser.

Mot denna bakgrund uppkommer ett flertal frågor: Hur kommer det sig att företag generellt inte delar information över fler led i försörjningskedjan trots att det, enligt litteraturen, anses värdefullt? Vidare, finns det några företag som implementerat informationsdelning över flera led och, i så fall, vilka är de verkliga fördelarna? Svaren på dessa frågor är begränsade i litteraturen. Den större delen av tidigare forskningsstudier har fokuserat på dyadiska relationer (dvs. säljare – köpare) och inte på hela försörjningskedjan. Syftet med avhandlingen är därför att gå utöver dyaderna och undersöka informationsdelning i försörjningskedjan, och utreda möjligheter och utmaningar med att dela information över flera led i försörjningskedjan. Syftet undersöks i en tredelad studie. Först utförs en strukturerad genomgång och analys av vetenskapliga publikationer. Därefter genomförs två empiriska studier: dels en fallstudie som beskriver en hel

försörjningskedja där data samlas in från flera led i kedjan, dels en så kallad Delphi-studie som syftar till att samla en panel av experter som i flera rundor ger input kring det fokuserade problemet.

Resultaten från de tre studierna pekar på att företag i stort undviker att dela information över flera led i försörjningskedjan. Detta beror på flera anledningar. För det första finns det en stor mängd hinder som gör det svårt att implementera informationsdelning. De största utmaningarna inkluderar brist på tillit mellan företag; brist på informationskvalitet för att använda som beslutsunderlag; svårigheter att rättvist fördela risker och eventuella vinster; avsaknad av sammanlänkade affärsprocesser; och avsaknad av en dominant spelar som kan genomdriva förändring i försörjningskedjan. Många företag är också upptagna med interna problem och har inte förmågan att engagera sig i informationsdelning mellan flera led i försörjningskedjan. För det andra verkar det som att informationsdelning över flera led endast är gynnsamt i särskilda sammanhang. Sådana sammanhang relaterar bland annat till planerade förändringar i försörjningskedjan såsom till exempel lansering av nya produkter. Dessutom verkar det som att ju mer gynnsamt sammanhang för informationsdelning desto svårare är det att implementera.

Vidare visar resultaten att företag fokuserar på att dela information med affärspartner som representerar hög grad av ömsesidigt beroende. Därmed sker det mesta informationsutbytet i dagens försörjningskedjor mellan dyadiska, strategiska samarbeten där företagen till exempel representerar en stor del av varandras omsättning. I fallet då man försöker koppla samman företag över flera led minskar det ömsesidiga beroendet eftersom företag ofta har ett mycket stort antal leverantörer och kunder. Därmed minska också viljan att dela information.

Avhandlingen, som är en av de första att studera informationsdelning i hela försörjningskedjan, pekar på att informationsdelning över flera led är ett sällsynt fenomen i industrin, och att det är många pusselbitar som måste falla på plats för att det ska gå att implementera och dra nytta av. Ett av bidragen med avhandlingen är ett ramverk som akademi och industri kan använda för att analysera och förstå informationsdelning över flera led. Ramverket kan användas dels för att vägleda framtida forskning dels för att ge beslutsstöd åt företag för att ta sig an och implementera informationsdelning över flera led.

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

ii. Kembro, J., Selviaridis, K., and Näslund, D. (2014). "Theoretical perspectives on information sharing in supply chains: a systematic literature review and conceptual framework." *Supply Chain Management: An International Journal* 19(5/6):609-625.

iii. Kembro, J. and Selviaridis, K. "Exploring information sharing in the extended supply chain: An interdependence perspective." Forthcoming in *Supply Chain Management: An International Journal* 20(4).

iv. Kembro, J., Olhager, J. and Näslund, D. "Importance and feasibility of multi-tier information sharing: findings from a Delphi study." Presented as full paper at the tenth European Research Seminar, 2015. To be submitted.

v. Kembro, J., Näslund, D. and Olhager, J. "Exploring challenges and barriers to multi-tier information sharing in supply chains." To be submitted.

Related publications

Kembro, J., and Näslund, D. (2011). "Information Sharing in the Supply Chain: An Exploratory Study." In The 23rd Annual NOFOMA Conference 749-765.

Kembro, J. (2012). "Understanding information sharing in supply chains-Identifying contingency factors that impact benefits of information sharing." Licentiate thesis, Lund University, Sweden

1 Introduction

1.1 Background and problem discussion

Managing relationships and business processes beyond the firm boundary, commonly referred to as supply chain management (SCM), has a multi-disciplinary origin with influences from many areas including logistics, operations management, transportation, purchasing, marketing, and information technology (Lambert *et al.*, 1998; Burgess *et al.*, 2006; Giunipero *et al.*, 2008). By developing relationships with supply chain partners, companies can mitigate uncertainty and exploit opportunities in order to improve profitability and competitiveness for the company as well as the entire supply chain (Lambert et al., 1998; Spekman et al., 1998). Ultimately, the aim of supply chain management is to lower costs, increase customer value and gain superiority over competitors (Christopher, 2005; Mentzer et al., 2001). Such an effort requires organizations to relinquish control over and engage in information sharing with supply chain partners.

Information sharing is recognized as a key construct of supply chain management and has been subject to a continuously growing stream of research studies (Lee and Wang, 2000; Mentzer *et al.*, 2001; Sahin and Robinson, 2002; Cousins *et al.*, 2006; Småros, 2007). According to several researchers, sharing information between partners is suggested to improve the performance of supply chains (Forrester, 1958; Lee and Wang, 2000; Hult *et al.*, 2004). Proposed benefits include improved forecasting, planning and scheduling in production, improved allocation and utilization of logistics resources, reduced bullwhip effect and lower inventory levels throughout the supply chain (Sterman, 1989; Mohr and Spekman, 1994; Cooper *et al.*, 1997; Seidmann and Sundararajan, 1998; Lee and Whang, 2000; Sahin and Robinson, 2002; Lee *et al.*, 2004; Zhou and Benton, 2007). Examples of companies that early on realized the potential benefits of sharing information with their supply chain partners include Wal-Mart Stores and one of its suppliers, Procter & Gamble, as well as Dell and one of its suppliers, Sony. As described by for example Mason-Jones & Towill (1997), Procter & Gamble agreed to receive point of sale (POS) information from Wal-Mart and, based on this information, they were able to decide what and how often they should deliver to the Wal-Mart stores to ensure that contracted service levels were met. Similarly, Dell designed an information system where customer orders were transmitted directly to its suppliers. By connecting the information systems, one of their suppliers, Sony,

could keep track of inventory levels, backlogs and, in some cases, ship directly to Dell's customers (Zhou and Benton, 2007). Further, by sharing information upstream in the supply chain, Dell and its partners improved responsiveness to upcoming demand and could thereby reduce inventory to cover only four days of supply (Fawcett *et al.*, 2009; Li *et al.*, 2006).

The examples of Wal-Mart and Dell's implementation of information sharing in their supply chains are unfortunately quite unique. Few companies have unlocked the potential benefits of information sharing (Fawcett *et al.*, 2009) and an increasing number of researchers recognize that information sharing across supply chains in reality is limited (see e.g. Kemppainen and Vepsäläinen, 2003; Uzzi and Lancaster, 2003; Roh *et al.*, 2008; Vanpoucke *et al.*, 2009). Moreover, it appears that the information sharing that does exist takes place mostly between dyads in supply chains and few, if any, firms engage in information sharing beyond the dyads (Kaipia and Hartiala, 2006; Taylor and Fearne, 2006; Caridi *et al.*, 2014). For instance, Taylor and Fearne (2006, p. 381) found that: *"in none of the chains studied was EPOS [i.e. electronic point of sale] data transferred further upstream than the retailer's immediate supplier."*

The predominant focus on dyadic information sharing becomes an issue considering that organizations continue to struggle with the bullwhip effect resulting in, for example, high inventory levels throughout their supply chains. The risk with dyadic information sharing is that the information is delayed and interpreted in each node of the supply chain. By the time the information reaches the upstream partners, it is less valuable to use the information for decision making in planning and scheduling of production and deliveries. Researchers therefore emphasize the need for companies to move beyond the dyads and increase information sharing across the supply chain (see e.g. Ogden *et al.*, 2005; Kaipia and Hartiala, 2006; Melnyk *et al.*, 2009). Mason-Jones and Towill (1999), for instance, submit that point of sale information should be shared as far upstream in the supply chain as possible. Melnyk *et al.* (2009) recommend managers to ensure seamless information sharing *"by involving the entire supply chain (both upstream and downstream) and working together collaboratively with secure and timely information flows between the parties"* (ibid, p. 4643). Similarly, Autry *et al.* (2014) recently discuss that *"the effort to connect the triad – and perhaps the broader supply chain, at further tiers – is worthwhile"* (ibid, p. 62) to achieve higher effectiveness and efficiency in the supply chain.

Against this background, several questions arise: first, why is there a lack of empirically based examples of this phenomenon reported in literature when academics and consultants seem to recommend practitioners to engage in information sharing across multiple supply chain tiers; second, looking at the empirical evidence, for what purpose and in which situations should companies move beyond the dyads and invest resources in implementing information sharing across multiple supply chain tiers (henceforth also referred to as multi-tier information sharing); and related, what are the empirical evidence of benefits related to sharing information across multiple tiers. In the search for answer these questions, there appears to be a gap in academic literature. Particularly, there seems to be a lack of studies moving beyond the dyads and applying the multi-tier supply chain as unit of analysis (see e.g. Choi and Liker, 2002; Li *et al.*, 2005; Autry *et al.*, 2014; Caridi *et al.*, 2014). Results are however frequently reported on the supply chain level indicating that previous research studies to some extent have disconnected the studied versus the reported unit of analysis. It also seems that the few studies that applied the supply chain as unit of analysis mostly investigate one-to-one relationships whereas existing supply chains are increasingly set up as networks of multiple relationships (cf. Choi and Hong, 2002). The network perspective considers multiple direct and indirect links between business partners where suppliers can offer their products and services to multiple customers and customers can source their products and components from multiple suppliers. The network of relationships also implies a range of interdependent activities and exchanges between various supply chain partners involved in production and distribution (Harland, 1996; Lamming *et al.*, 2000).

1.2 Purpose and research questions

In light of the background and problem discussion, there may be situations where companies need to move beyond the dyads in order to further reduce the bullwhip effect, lower inventory holding costs and improve service levels to their customers. However, there is a lack of empirical research moving beyond the dyads and as a result we lack understanding of how managers should address information sharing across several supply chain tiers. The purpose of this dissertation is therefore *to investigate information sharing in multi-tier supply chains, as well as to explore opportunities and challenges to sharing information beyond the dyadic relationships*. To address this purpose, four research questions are sought to be answered.

RQ1: To what extent does empirical evidence exist of multi-tier information sharing and related benefits?

The first research question represents the starting point of this dissertation. By answering this question, the aim is to establish if there is any empirical support for the claims that information sharing should be increased across multiple supply chain tiers. Related, as previously discussed, it appears that previous research has disconnected the studied and the reported unit of analysis. The majority of empirical research has focused on the dyadic relationships whereas results are often reported on the supply chain level. Therefore, the aim is also to investigate if there really is a disconnection. The research question is addressed through a systematic literature review, setting the stage for the following empirical studies. The empirical evidence of multi-tier information sharing and related benefits are thereafter explored in two empirical studies; first, through an in-depth case study (Yin, 2014); and second, through an extensive Delphi study (Linstone and Turoff, 2002; Melnyk *et al.*, 2009).

RQ2: How can different theories be used and combined to analyze and better understand information sharing in multi-tier supply chains?

Theories can be helpful to improve the description, explanation and predictions of complex phenomena such as multi-tier information sharing (cf. Halldorson and Aastrup, 2003; Carter and Rogers, 2008; Defee *et al.*, 2010). It is important to consider different theoretical perspectives, acknowledging that our access and understanding of the world is limited and determined by our preconceived knowledge of phenomena (Hanson, 1958; Alvesson and Kärreman, 2011; Mingers *et al.*, 2013; Volkoff and Strong, 2013). Hence, as argued by Nilsson and Gammelgaard (2012), applying different theories may help to increase our understanding of the researched phenomenon.

By exploring which theories have been used in previous research and how the theories have been used (i.e. related to different aspects and themes brought forward by the various theories), a conceptual framework is developed and presented in paper ii (cf. Figure 7). The framework was used to guide the two empirical studies in terms of which theoretical perspectives that were

considered. The theories were later reconsidered in the iterative process of analyzing the collected data, allowing the researchers to view the data sets from different angles and perspectives. To help increase our understanding of multi-tier information sharing in supply chains, this dissertation primarily relies on contingency theory and interdependence theory.

RQ3: What are the challenges and barriers to multi-tier information sharing?

Existing literature highlights several reasons why companies may choose not to share information with their supply chain partners. Examples include the increased complexity, costs and risks (Kemppainen and Vepsäläinen, 2003; Roh *et al.*, 2008) and the fact that managers often are disappointed by the low cost/benefit ratio of resources invested into information sharing (Vanpoucke *et al.*, 2009). Managers are also concerned with the potentially reduced competitiveness of the company (Uzzi and Lancaster, 2003) and perceive the task of determining what should be shared with whom to be quite difficult, taking into account that supply chains tend to evolve over time and require involvement by many different partners (Samaddar *et al.*, 2006).

Building on RQ1 and RQ2, the aim of the third question is to move beyond the commonly researched dyads and increase our understanding of the various challenges that need to be addressed to enable multi-tier information sharing. In the words of Li and Lin (2006, p. 1642) *"an understanding of the factors influencing information sharing is needed so that a strategy may be developed to overcome the barriers preventing information sharing and encourage seamless information flow in supply chains."* The third research question is addressed through both of the empirical studies. First, the case study offers insights to how firms work with information sharing in an extended supply chain (also referred to as a supply network, see e.g. Choi and Hong, 2002). The case study also provides insights to potential barriers and related issues preventing multi-tier information sharing in the supply chain. Second, based on the results from the case study, the Delphi study further explores the difficulties and potential obstacles to implementing information sharing beyond the dyads.

RQ4: How do importance and feasibility of multi-tier information sharing inter-relate?

A growing stream of literature argues that information sharing only is beneficial in certain contexts. This approach builds on the paradigm of contingency theory which holds that there is no one-size-fits-all approach to designing an organization. Instead, structures and processes should be adapted to the context in order to maximize performance (Woodward, 1965; Donaldson, 2001). Applied to the topic of information sharing in supply chains, managers are thus urged to adapt information sharing to the particular context of the supply chain (see e.g. Li *et al.*, 2006; Grover and Saeed, 2007; Butterman *et al.*, 2008; Flynn *et al.*, 2010). For example, information sharing should be increased in contexts representing high structural complexity of supply chains (Caridi *et al.*, 2010), high product complexity (Grover and Saeed, 2007) and high demand uncertainty (Lee and Whang, 2000). On the contrary, information sharing should not be increased in supply chains manufacturing and distributing products representing low complexity and stable demand patterns (Kim *et al.*, 2006).

The contingency perspective of multi-tier information sharing is investigated through the fourth research question. Particularly, previous research suggests that multi-tier information sharing could be beneficial in certain contexts but at the same time involves several challenges that must be resolved. Companies therefore need to understand how importance, in terms of potential benefits, and feasibility of implementing information sharing interact with each other. The fourth research question is addressed through the Delphi study.

1.3 Connecting research questions with studies and publications

Each of the four research questions are addressed in five separate but connected papers listed below. An overview of the connection between research questions and related studies and papers is presented in Table 1.

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

ii. Kembro, J., Selviaridis, K., and Näslund, D. (2014). "Theoretical perspectives on information sharing in supply chains: a systematic literature review and conceptual framework." *Supply Chain Management: An International Journal* 19(5/6):609-625.

iii. Kembro, J. and Selviaridis, K. "Exploring information sharing in the extended supply chain: An interdependence perspective." Forthcoming in *Supply Chain Management: An International Journal* 20(4).

iv. Kembro, J., Olhager, J. and Näslund, D. "Importance and feasibility of multi-tier information sharing: findings from a Delphi study." Presented as full paper at the tenth European Research Seminar, 2015. To be submitted.

v. Kembro, J., Näslund, D. and Olhager, J. "Exploring challenges and barriers to multi-tier information sharing in supply chains." To be submitted.

Table 1 - Connection of the publications (P1-5) to the research questions (i-iv).

		Literature review		Case study	Delphi study	
RQ	Description	P1	P2	P3	P4	P5
i	To what extent does empirical evidence exist of multi-tier information sharing and related benefits?	*X*		*X*	*X*	
ii	How can different theories be used and combined to analyze and better understand information sharing in multi-tier supply chains?		*X*	*X*		*X*
iii	What are the challenges and barriers to multi-tier information sharing?			*X*		*X*
iv	How do importance and feasibility of multi-tier information sharing inter-relate?				*X*	

1.4 Defining information sharing in supply chains

The term information sharing has been defined in many different ways (cf. Mohr and Spekman, 1994; Mentzer *et al.*, 2001; Whadwa and Saxena, 2007; Cao *et al.*, 2010). Mohr and Spekman (1994, p. 139), for example, define information sharing as *"The extent to which critical, often proprietary, information is communicated to one's partner"* whereas Mentzer *et al.* (2001, p. 8) define it as *"The willingness to make strategic and tactical data available to other members of the supply chain"*. An overview of various definitions of the term information sharing is presented in Table 2.

Table 2 - Overview of various definitions of the term information sharing.

Definition	Reference
The extent to which critical, often proprietary, information is communicated to one's partner.	Mohr and Spekman (1994)
The willingness to make strategic and tactical data available to other members of the supply chain.	Mentzer *et al.* (2001)
The availability of online information of retailers' inventory positions to suppliers.	Moinzadeh (2002)
The dissemination of timely and relevant information across interdependent firms to enable decision makers to plan and control supply chain operations.	Simatupang and Sridharan (2004)
The sharing of end customer demand and lead time.	Wadhwa and Saxena (2007)
The extent to which crucial and/or proprietary information is available to supply chain partners.	Hsu *et al.* (2008)
The process of transmission of information from one supply chain member to another.	Sepulveda Rojas and Frein (2008)
The extent, to which a firm shares a variety of relevant, accurate, complete and confidential ideas, plans, and procedures with its supply chain partners in a timely manner.	Cao *et al.* (2010)
The extent to which data is accessible to partner firms through mutually agreed exchange infrastructure.	Olorunniwo and Li (2010)
The act of capturing and disseminating timely and relevant information for decision makers to plan and control supply chain operations.	Wiengarten *et al.* (2010)
The sharing of each firm's private information among supply chain members.	Hung *et al.* (2011)

In this dissertation, the focus is on demand-related information sharing (henceforth referred to as information sharing) considering, for example, order information (Klein and Rai, 2009) and demand or sales data (Patnayakuni *et al.*, 2006), quarterly forecasts (Bowersox *et al.*, 2000), plans and trends (Yigitbasioglu, 2010; Ramanathan, 2012), as well as one-year forecasts, sales promotion and marketing strategies (Mentzer *et al.*, 2001).

Further, for the purpose of this dissertation, the definition of a supply chain is adopted from Mentzer *et al.* (2001, p. 4) as: *"[. . .] a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer."* A single company or a dyadic relationship is thus not considered to constitute a supply chain; they are parts of a supply chain. A supply chain could include, for example, supplier-manufacturer-customer where the extended supply chain also involves suppliers' suppliers and customers' customers, see Figure 1.

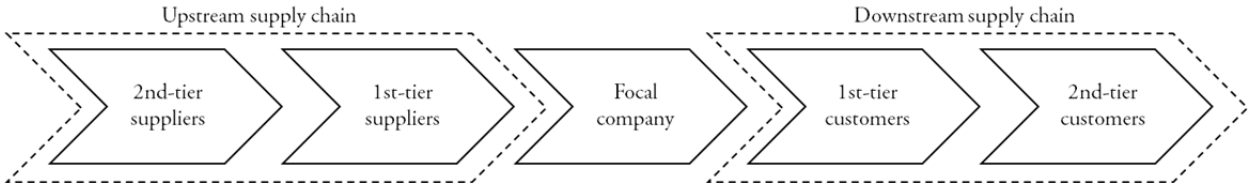

Figure 1 - The extended supply chain (Mentzer *et al.*, 2001)

The term *multi-tier information sharing in supply chains* (hereafter referred to as just multi-tier information sharing) thus signifies organizations sharing demand-related information beyond the dyads, involving three or more independent supply chain partners. Examples are illustrated in Figure 2.

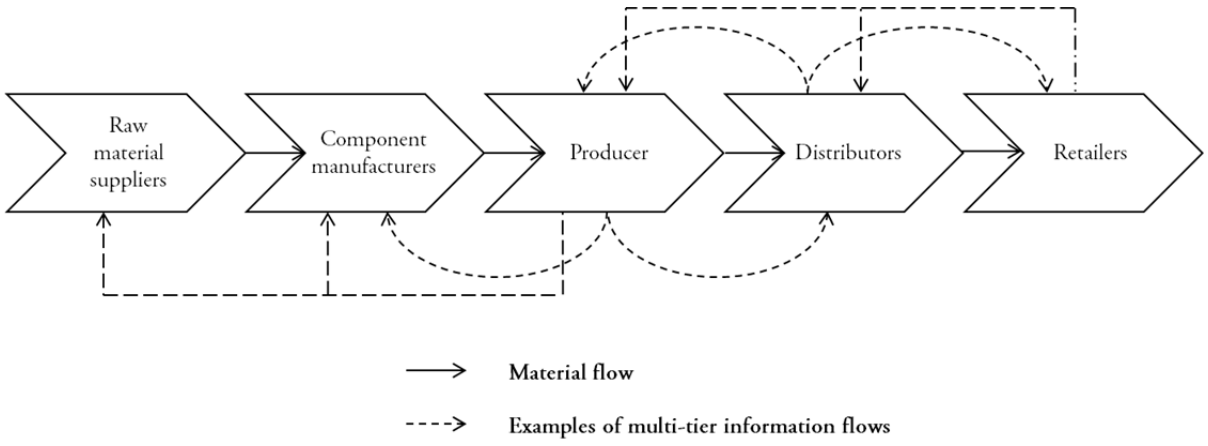

Figure 2 - Examples of multi-tier information sharing in a supply chain.

As illustrated in Figure 2, the focus is on the business-to-business setting. As part of the order fulfillment process, it is assumed that there is a material flow between the dyadic partners (cf. Lambert and Cooper, 2000). For example, material is supplied from the component manufacturers to the producer and from the producer to the distributors, but not directly from component manufacturers to the distributors. Related, it is expected that one or more of the involved partners carry out production or assembly of one or more products and/or components. Further it is assumed that the shared information is not being interpreted, aggregated or in any other way analyzed and organized by a dyadic partner before transmitted further upstream. However, the information may very well be routed through the connected dyad. For instance, the focal company may have an information system in place that facilitates the information sharing between the first-tier customer and first-tier supplier. Figure 2 also shows that information can flow in both directions. Information flowing downstream could for example include order acceptance, confirmation of available capacity in production or notification of delayed delivery.

1.5 Delimitations

There are a number of delimitations that are important to consider. First, the focus is not on intra-organizational information sharing. Second, information sharing not related to demand information (e.g. product development) will be disregarded. Third, the thesis will neither discuss nor make any particular distinction between data, information and knowledge. Yet, the author recognizes that there are streams of research focusing on each of these separately (e.g. knowledge management). Particularly, the distinction between data, information and knowledge could be relevant when discussing different ways for sharing. This thesis will however not focus on the means for sharing, i.e. "how" companies share information through various meetings, telephone conferences and/or information systems. Further delimitations relate to the exclusion of financial providers and logistics service providers including, for example, transporting between supplier and buyer of a particular product. Also, the thesis focuses on the business-to-business context including one or more manufacturing processes. Pure retailing or distribution cases are thus not considered in this dissertation. Related, it is assumed that material flows in sequential order between the partners. Cases where material is shipped directly from, for example the first-tier supplier to the end consumer are therefore excluded.

1.6 Structure of thesis

This dissertation includes a summary and analysis of the five appended papers. In the next chapter, the frame of reference is presented including benefits of and challenges to information sharing. The frame of reference, which also includes a description of contingency theory and interdependence theory, is summarized by presenting a framework for analyzing and understanding information sharing in supply chains. In chapter three, the methodology is described. Initially, a discussion is included regarding ontology and epistemology describing my perspective as a critical realist. Thereafter, the overall research structure and the design of the pilot study as well as each of the three included studies is presented and described. The methodology chapter ends with a discussion on research quality of the dissertation, considering aspects such as triangulation and trustworthiness of the results presented in the research studies. In chapter four, each of the five papers is presented with purpose, findings and implications. Thereafter, in chapter five, the appended papers are analyzed together, resulting in a framework for multi-tier information sharing. Finally, the purpose and research questions are revisited and answered. Implications are discussed, and theoretical, managerial and methodological contributions of this dissertation are highlighted. Thereafter, limitations and several opportunities for future research are discussed before ending with a concluding discussion.

2. Frame of reference

The frame of reference includes literature on various aspects of information sharing in multi-tier supply chains. First, different types and scope of information sharing are presented together with recognized benefits. Thereafter, various challenges to information sharing are described followed by an overview of the two theories that are used to analyze part of the collected data, namely contingency theory and interdependence theory. The frame of reference is summarized by presenting a framework for analyzing and understanding information sharing in supply chains. The suggested framework will thereafter be developed based on the findings from the appended papers. The developed framework is presented in chapter 5.

2.1 Information sharing in supply chains

Information sharing is recognized as one of the three flows that must be integrated and optimized to improve coordination and planning in the supply chain (Cooper *et al.*, 1997; Mentzer *et al.*, 2001; Fawcett *et al.*, 2009). Information sharing can, for example, help to reduce demand uncertainty and counter the phenomenon known as the bullwhip effect and thereby allow supply chain partners to better plan production and distribution (Forrester, 1958; Sterman, 1989; Lee *et al.*, 2004; Nyaga *et al.*, 2010).

Inter-organizational information sharing can occur at three different organizational levels, namely operational, tactical and strategic (cf. Houlihan, 1987; Stevens, 1993; Näslund, 1999), where each organizational level represents a decision time horizon for which the shared information is intended (Huang *et al.*, 2003): operational, less than 2 weeks; tactical, 2 weeks to 6 months; strategic, more than 6 months. On the operational level, information sharing includes order information and sales data, which is used to facilitate orders and reduce information distortion and stock levels (Patnayakuni *et al.*, 2006; Klein and Rai, 2009; Yu *et al.*, 2010). On the tactical level, companies share monthly and quarterly forecasts, plans and trends to allow the upstream partner to reserve adequate capacities for production and logistics (Bowersox *et al.*, 2000, Patnayakuni *et al.*, 2006; Klein and Rai, 2009; Yigitbasioglu, 2010; Ramanathan, 2012). On the strategic level, information sharing includes yearly demand plans, sales promotion and marketing strategies, which could help to plan future purchases and growth within the alliance (Mohr and

Spekman, 1994, Mentzer *et al.*, 2001). An overview of different types of shared information and potential benefits is displayed in Table 3.

Table 3 - Different types of shared information and related benefits.

Organizational level	Type of information sharing	Potential benefits	Reference
Operational	Order information and sales data.	Can be used to facilitate orders and reduce information distortion and stock levels.	Patnayakuni *et al.* (2006); Klein and Rai (2009); Yu *et al.* (2010)
Tactical	Monthly and quarterly forecasts, plans and trends.	Can help the upstream partner to reserve adequate capacities for production and logistics.	Bowersox *et al.* (2000); Patnayakuni *et al.* (2006); Klein and Rai (2009); Yigitbasioglu (2010); Ramanathan (2012)
Strategic	Yearly demand plans, sales promotion and marketing strategies.	Could help firms to plan future purchases and growth within the alliance.	Mohr and Spekman (1994); Mentzer *et al.* (2001)

To realize the claimed benefits, information can be shared between different members in the supply chain. For example, Zhang (2008) differs between monolayer and multilayer information sharing. Monolayer represents information sharing between dyadic partners whereas multilayer signifies information sharing beyond the dyads. Similarly, other researchers including Strader *et al.* (1999) and Fabbe-Costes and Jahre (2007) recognize that information can be shared between partners representing different tiers in the supply chain. They differ between upstream and downstream sharing as well as dyadic, triadic and extended sharing.

2.2 Challenges to information sharing

Considering the claimed benefits, authors emphasize the need for increased information sharing between dyadic partners as well as across multiple tiers in the extended supply chain (see e.g. Van Ackere *et al.*, 1993; Greis and Kasarda, 1997; Chen *et al.*, 2000; Sahin and Robinson 2002; Ogden *et al.*, 2005; Ketzenberg *et al.*, 2007; Sepulveda Rojas and Frein, 2008; Caridi *et al.* 2010; Yu *et al.*, 2010). While the benefits appear theoretically sound, companies seem to struggle with implementing information sharing in their supply chains (Moberg *et al.*, 2002; Wang *et al.*, 2008; Nakano, 2009). Few companies have unlocked the potential of seamless connectivity, partly due to an over-reliance on technological solutions and lack of understanding of organizational cultures and structures (Barratt, 2004; Kaipia and Hartiala, 2006; Taylor and

Fearne, 2006; Fawcett *et al.*, 2007; Fawcett *et al.*, 2009). To address this issue, previous research has identified a number of challenges that companies need to resolve in their supply chains (Angulo *et al.*, 2004). An overview of challenges identified in literature are presented in Table 4.

Table 4 - Challenges to information sharing in supply chains.

Challenge	Description	References
Lack of trust	Fear of opportunistic behavior may reduce willingness to share due to the risk of information leakage to competitors.	Moorman *et al.* (1992); Cooper *et al.* (1997); Seidmann and Sundararajan (1998); Spekman *et al.* (1998); Moberg *et al.* (2002); Barratt (2004); Kelle and Akbulut (2005); Li and Lin (2006); Fawcett *et al.* (2007); Klein and Rai (2009); Porterfield *et al.* (2010);
Confidential information	Fear of losing control of sensitive data that could reduce competitiveness in the marketplace.	Lee and Whang (2000); Frohlich (2002); Lau *et al.* (2004); Kelle and Akbulut (2005); Li and Zhang (2008)
Power asymmetry	Fear amongst partners to become dependent on each other. Also, the dominant player could fear losing the current favorable position and bargaining power in a supplier-buyer relationship.	Seidmann and Sundararajan (1998); Mason-Jones and Towill (1999); Ballou *et al.* (2000); Christopher and Jüttner (2000); Lee and Whang (2000); Frohlich (2002); Li and Lin (2006); Fawcett *et al.* (2007); Harland *et al.* (2007);
Inadequate information systems	Supply chain members may have different systems in place which are not compatible, and the implementation of new IT systems may be negatively perceived due to lack of incentives.	Christopher and Jüttner (2000); Lee and Whang (2000); Frohlich (2002); Childerhouse *et al.* (2003); Shore and Venkatachalam (2003); Kelle and Akbulut (2005); Patnayakuni *et al.* (2006); Fawcett *et al.* (2007); Harland *et al.* (2007); Fawcett *et al.* (2008);
Implementation costs	The means for sharing information may require high capital investments.	Christopher and Juttner (2000); Lee and Whang (2000); Childerhouse *et al.* (2003); Fawcett *et al.* (2007)
Lack of information quality	Without proper formatting, timeliness and reliability, the shared information is of little value to the receiver.	Monczka *et al.* (1998); Lee and Whang (2000); Moberg *et al.* (2002); Childerhouse *et al.* (2003); Angulo *et al.* (2004); Barratt (2004); Li and Lin (2006); Li *et al.* (2006); Forslund and Jonsson, 2007
Unfair benefits allocation	Unfair distribution of rewards of information sharing between involved partners.	Mason-Jones and Towill (1999); Ballou *et al.* (2000); Lee and Whang (2000); Childerhouse *et al.* (2003); Sahin and Robinson (2005); Harland *et al.* (2007); Fawcett *et al.* (2008)
Common performance metrics	Lack of common performance indicators for capturing benefits related to inter-organizational information sharing.	Ballou *et al.* (2000); Barratt (2004); Kelle and Akbulut (2005); Fawcett *et al.*, (2008)
Lack of shared vision	Diverse goals of partners make it difficult to achieve necessary changes in business culture for enabling information sharing.	Kelle and Akbulut (2005); Harland *et al.* (2007); Fawcett *et al.* (2008)
Governance	Due to the disintegrated structures of supply chain, there is a lack of governance how the chain is directed and controlled.	Childerhouse *et al.*, 2003; Fawcett *et al.* (2008)

One of the major challenges highlighted in previous literature is (the lack of) trust between business partners (e.g. Barratt, 2004; Fawcett *et al.*, 2007). Trust, defined as *"a willingness to rely on an exchange partner in whom one has confidence"* (Moorman *et al.*, 1992, p. 315) can be regarded as a mutual agreement between partners to refrain from opportunistic behavior (Li and Lin, 2006). Lack of trust may thus increase the fear of opportunism and reduce companies' willingness to share information (Cooper *et al.*, 1997; Spekman *et al.*, 1998; Klein and Rai, 2009). Related to the lack of trust, companies may fear losing control over confidential information (Lau *et al.*, 2004), which in the wrong hands could reduce the competitiveness of the firm. Managers should therefore *"consider the tradeoffs between information exchange that enhances performance and information exchange that allows trading partners to act opportunistically"* (Porterfield *et al.*, 2010, p. 451).

Power asymmetry is another well researched challenge (e.g. Mason-Jones and Towill, 1999; Ballou *et al.*, 2000). Power, defined as *"the amount of resistance on the part of B which can be potentially overcome by A"* (Emerson, 1962, p. 32), signifies the control an organization has over things that are valued by its partners. Power is therefore, according to Emerson (1962), related to the weaker partners' dependency and few alternatives to accomplish their goals. Firms often compete for power to increase their competitiveness (Frohlich, 2002). Sharing information can however be perceived as a loss of power and companies may fear to become overly dependent (Mason-Jones and Towill, 1999) or lose a favorable position to negotiate with their partners (Seidmann and Sundararajan, 1998). The weaker party may therefore seek to refrain from sharing information. Lee and Whang (2000, p. 14) elaborates on this notion: *"a power monopolistic or monopsonistic partner can extract all economic profit from his or her partner, but one way of defending a positive profit for the weaker party is to keep the cost hidden and maintain informational superiority."* Meanwhile, the dominant player could use its power to force other firms to share information (Ballou *et al.*, 2000). Power asymmetry could therefore be perceived to have both negative and positive effect on implementing information sharing in supply chains.

Other challenges that are frequently discussed in literature include inadequate and costly information systems (e.g. Frohlich, 2002; Kelle and Akbulut, 2005; Harland *et al.*, 2007), and lack of information quality (e.g. Lee and Whang, 2000; Childerhouse *et al.*, 2003; Barratt, 2004). Implementing information systems can be an expensive, time-consuming and risky undertaking,

particularly considering the complex and dynamic structures of supply chains Nonetheless, information sharing involves the collection and analysis of large data sets and requires all the key players to be connected (Fawcett *et al.*, 2007; Fawcett *et al.*, 2008). The lack of connected information systems can result in lack of accuracy, timeliness and proper formatting of information, also referred to as information quality (Moberg *et al.*, 2002; Angulo *et al.*, 2004; Li and Lin, 2006; Forslund and Jonsson, 2007). Lack of information quality implies that the information has little or no value and can even be detrimental for decision making among upstream supply chain partners (Monczka *et al.*, 1998; Lee and Whang, 2000; Li *et al.*, 2006).

Previous literature has also highlighted issues related to measuring and sharing benefits between the supply chain partners (see e.g. Sahin and Robinson, 2005; Harland *et al.*, 2007; Fawcett *et al.*, 2008). Companies are often legally separate and have different performance metrics and reward systems in place (Ballou *et al.*, 2000). It may therefore be an issue to agree on how benefits of inter-organizational information sharing are measured and distributed fairly among the supply chain partners (Mason-Jones and Towill, 1999; Childerhouse *et al.*, 2003). Instead, there is a risk that only one partner reap the benefits (Lee and Whang, 2000). To address this issue and ensure that benefits are fairly allocated between the involved partners, several authors argue for the need to develop a common set of supply chain metrics (see e.g. Ballou *et al.*, 2000; Barratt, 2004).

Finally, previous research has discussed the lack of shared vision between supply chain partners (e.g. Kelle and Akbulut, 2005; Fawcett *et al.*, 2008) and issues related to supply chain governance (Childerhouse *et al.*, 2003). Supply chain partners in general have multiple suppliers and customers, each having their own goals and priorities. Diverse priorities could make it difficult to make necessary changes for implementing information sharing (Harland *et al.*, 2007). The disintegrated structures of supply chains also make it difficult to direct and control supply chain partners, which may be needed to implement information sharing (Childerhouse *et al.*, 2003).

2.3 A contingency approach to information sharing

Considering both claimed benefits and suggested challenges, a growing stream of research submits that information sharing should be adapted to the supply chain context in order to improve performance. In other words, it may not always be beneficial to increase information sharing in

supply chains; rather, it depends (e.g. Kim *et al.*, 2006; Samaddar *et al.*, 2006; Caridi *et al.*, 2010; Wong *et al.*, 2012).

Contingency theory recognizes that there is no one best way to design an organization. Instead, organizations can improve performance by matching structures and processes to the particular context (Woodward, 1965; Lawrence and Lorsch, 1967; Thompson, 1967). Applied to the information sharing in supply chains, the theory suggests that it is critical to consider the supply chain context in order to determine what information to share with which partner (Roh *et al.*, 2008; Sousa and Voss, 2008). Otherwise, firms may waste organizational resources without attaining significant benefits such as improved production plans and lowered inventories (e.g. Persson, 1995; Butterman *et al.*, 2008; Flynn *et al.*, 2010). This prediction is illustrated in Figure 3. Lower performance is expected if there is a misfit between information sharing, i.e. what information is shared with whom, and the contingency factors. According to the theory, it is possible that more than one contingency variable impact the structural variable and the effect of each contingency factor can be added to the others in order to determine if there is a fit or misfit. Thus, the effect is said to be additive (Donaldson, 2001).

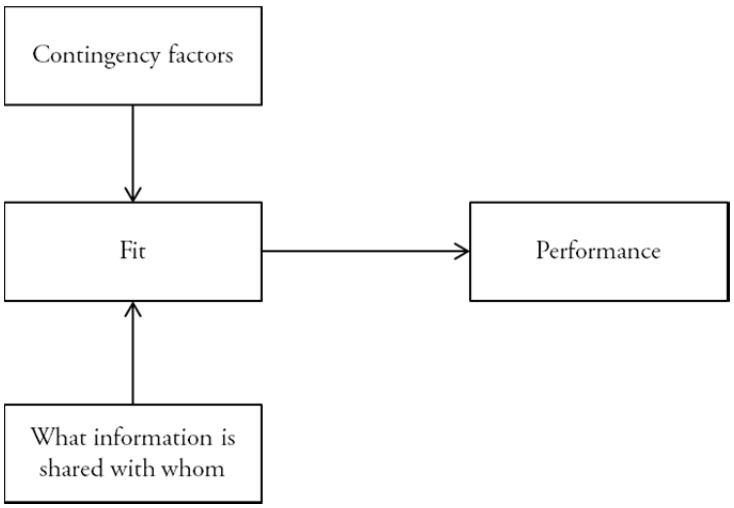

Figure 3 - Prediction of contingency theory (based on Donaldson, 2001).

Previous research studies have submitted several contextual factors that should be considered for designing supply chain processes in general, and dyadic information sharing in particular. An overview of discussed factors is included in Table 5. Examples include structural complexity of the supply chain (Persson, 1995), lead times in the supply chain (Christopher and Towill, 2002) and decoupling and customization point (Holweg, 2005). Other factors related to product characteristics include product life cycle (Yigitbasioglu, 2010), structural complexity of product, commonly referred to as the bill of material (Persson, 1995; Vanpoucke *et al.*, 2009), as well as demand uncertainty (Fisher, 1997; Lee, 2002).

Table 5 - Examples of contextual factors submitted in previous research studies.

Aspect	Contextual factor	References
Product and market	Product life cycle	Cigolini *et al.* (2004); Holweg (2005); Ketzenberg *et al.* (2007); Yigitbasioglu (2010)
	Structural complexity of product	Cigolini *et al.* (2004); Kim *et al.* (2006); Grover and Saeed (2007); Vanpoucke *et al.* (2009); Wong *et al.* (2012)
	Demand uncertainty	Fisher (1997); Lee and Whang (2000); Lee (2002); Kim *et al.* (2006)
Supply chain	Structural complexity of the supply chain	Persson (1995); Caridi *et al.* (2010); Samaddar *et al.* (2006)
	Lead times in the supply chain	Christopher and Towill (2002); Christopher *et al.* (2006)
	Decoupling and customization point	Holweg (2005); Van der Vaart and van Donk (2006)

Considering the range of contextual factors, previous studies have suggested favorable, dyadic supply chain settings where information sharing should be increased to improve performance. Such settings include munificent supply chains (Wong *et al.*, 2012), high structural complexity of supply chains (Caridi *et al.*, 2010), high product complexity (Grover and Saeed, 2007), high demand uncertainty (Lee and Whang, 2000). In contrast, unfavorable settings include products representing low complexity and low demand uncertainty (Kim *et al.*, 2006). Increasing information sharing in such unfavorable settings could result in information leading to delayed and inadequate decision making in, for instance, production and distribution (Persson, 1978; Butterman *et al.*, 2008; Flynn *et al.*, 2010).

Contingency theory has, over time, been developed and extended into several branches. Examples include the information processing theory and configuration theory. Information processing

theory holds that information sharing should be adapted to the perceived uncertainty of the task to be carried out. Galbraith (1974, p. 28) elaborates: *"the greater the task uncertainty, the greater the amount of information that must be processed among decision makers during task execution in order to achieve a given level of performance"*. Configuration theory, which has been widely used in management research, predicts that the fit between contingency and structural variables are restricted to a limited number of configurations or gestalts (Flynn *et al.*, 2010). An argued benefit of this perspective is that *"it takes a more holistic approach and recognizes that many organizational constructs are not easily characterized by simple continuous or bivariate statistical relationships."* (Stock *et al.*, 2000, p. 533) This argument is supported by, for example, Sayer (2000) who submits that *"the world is characterized by emergence, that is situations in which the conjunction of two of more features or aspects gives rise to new phenomena, which have properties which are irreducible to those of their constituents"* (ibid, p. 12). In other words, it is recommended to consider a system as a whole rather than reduce it to isolated contextual factors.

2.4 An interdependence perspective on information sharing

Another theory which relates to the contingency approach is interdependence theory. The interdependence perspective has not been applied frequently to investigate information sharing in supply chains but could be useful to understand how companies adapt information sharing to the supply chain context (see e.g. Danese *et al.*, 2004). Interdependence theory has its origin in organization theory and the seminal work of Thompson (1967). The theory suggests that a group of connected actors, to a varying degree, depend on each other to achieve their respective goals (Gomes and Dahab, 2010). Interdependence thus emerges when both buyers and suppliers can exert power to each other (Cox, 2004). In other words, related to power-dependence theory (Emerson, 1962), interdependence resides in the mutual control companies have over the things valued by their respective partners.

Interdependence can be categorized either according to intensity or type. Features representing the intensity of interdependence (i.e. either weak or strong) include the number of potential buyers and suppliers; share (in %) of total market for supplier; switching costs and; uniqueness in offerings (Cox, 2004). Related, Thompson (1967) identified three types of interdependence, namely serial, reciprocal and pooled. Serial, or sequential, interdependence exists through links

between tasks where the input of one part is directly dependent on output from another whereas reciprocal interdependence represents mutual exchange of inputs and outputs with each company posing contingency for the other. Pooled interdependence represents two activities that are not directly connected with each other but share common resources and together contribute to a system output. This notion is further described by Thompson (1967, p. 54) as *"each part renders a discrete contribution to the whole and each is supported by the whole"*.

The three types of interdependencies can be useful to understand the mechanics of supply chains as networks of exchange relationships (Harland, 1996; Skipper *et al.*, 2008). Dubois *et al.* (2004, p. 6) discuss that *"[t]he supply chain concept relies strongly on the notion that there is sequential interdependence among activities which, therefore, need co-ordination"* in order to, for example, increase output, reduce costs or increase the service level to customers. Reciprocal interdependencies can also be considered to exist in supply chains where partners interact through information exchange, joint forecasting and planning of procurement and production. Dubois *et al.* (2004, p.6-7) further describes: *"where ex ante matching of plans is required, firms need to interact in order to make the plans fit into their different production contexts. This interaction may also include adjustments of resources used in, or refined by, the activities subject to coordination to improve resource utilisation or the means by which the activities are co-ordinated."* Finally, pooled interdependencies exist in supply chains considering the average number of companies that are involved in a supply chain and acknowledging that firms are members of several different supply chains and thus represent a range of activities and resources that need to be integrated. In a sense, different supply chains compete for the same resource where each organization can have different focus and different role in the various supply chains (Lamming *et al.*, 2000).

2.5 Synthesis of related literature

Previous literature has discussed potential benefits of information sharing in supply chains and also identified several challenges. As the research area has matured, a growing number of researchers have recognized that information sharing may not be beneficial in all supply chains but rather should be adapted to the particular context. Previous research has however predominantly discussed dyadic relationships, and only a handful studies have moved beyond the dyads and applied the extended supply chain as unit of analysis. Hence, there is a need to further

explore information sharing across multiple tiers to understand the potential benefits as well as challenges that must be resolved. To summarize the literature review, a tentative framework for analyzing and understanding information sharing in multi-tier supply chains is developed and presented in Figure 4.

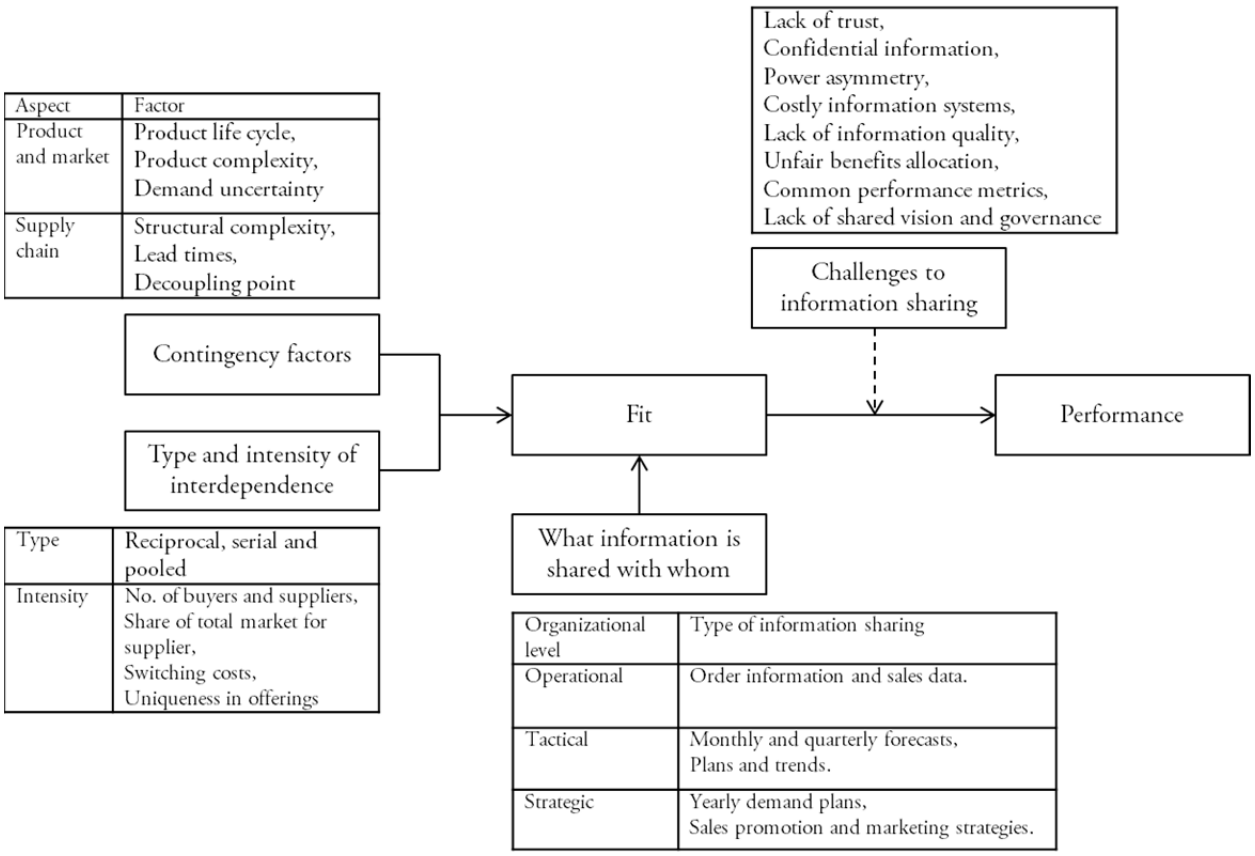

Figure 4 - A framework for analyzing information sharing in multi-tier supply chains.

The framework illustrated in Figure 4 displays how information sharing, through matching with the supply chain contexts and type and intensity of interdependence, can potentially lead to increased performance for the involved supply chain partners. As shown in Figure 4, information sharing can occur on three organizational levels between dyadic partners and between firms representing multiple supply chain tiers. The framework also highlights that several challenges must be resolved to enable information sharing in supply chains. For instance, in case information quality is low or there is a lack of trust between partners, increased information sharing may be difficult and could, in worst case, lead to wasted resources and misinformed decision making throughout the supply chain.

3. Methodology

I will begin the methodology chapter by discussing my perspective on and understanding of reality and what constitutes knowledge and the acquiring and creation of it. Thereafter, the overall research structure is described, detailing the research design for each of the three studies included in this dissertation. Finally, research quality is discussed considering aspects such as triangulation and trustworthiness.

3.1 Ontology and epistemology: a critical realist perspective

3.1.1 Two sides of knowledge

The term and philosophy "critical realism" was developed by the British philosopher Roy Bhaskar. In contrast to, for example, positivism and constructivism, critical realism supports the notion that an external reality (i.e. the intransitive domain) exists independently of our knowledge (of it) (see Bhaskar, 1975). As simply stated by Sayer (2000, p.2), *"the world exists regardless of what we happen to think about it"*. The creation of knowledge of the intransitive domain, however, is an activity that is carried out by humans and thus depends upon the particular process and details of its generation such as, for example, theories, models and data collection methods (Archer *et al.*, 1998; Saunders *et al.*, 2007). In the words of Bhaskar (1975, p. 21): *"men in their social activity produce knowledge which is a social product much like any other, which is no more independent of its production and the men who produce it than motor cars, armchair is or books, which has its own craftsmen, technicians, publicists, standards and skills and which is no less subject to change than any other commodity"*.

3.1.2 The real, the actual and the empirical

Critical realism makes a distinction between the real, the actual and the empirical domain (Sayer, 2000). The real can be described as *"whatever exists, be it natural or social"* (ibid, p. 11) and represents the realm of objects as well as their structures and causal powers, of which the latter may exist unexercised. The actual refers to what transpires if and when the powers of objects are activated. Finally, Sayer (2000) continues, the empirical represents the domain of experience of the real or the actual. We may be able to observe some objects and structures while we cannot

observe others. Observability may convince us of what we believe exists, but as previously noted, the external reality does not depend on our ability to observe it. Instead, critical realism considers a causal criterion. In other words, it is possible to make claims of the intransitive domain and what exists based on observable effects of unobservable objects. In summary, Sayer (2000) argues, the world should not be confused with our experience or knowledge of it, i.e. the real is not necessarily what we experience. Along the same line of reasoning, the intransitive domain does not change just because our theories (as part of the transitive domain) change. As an illustrative example, earth itself did not necessarily change just because the theory of a flat earth was replaced by a theory of a round earth (ibid).

3.1.3 Social science and the importance of contextual factors

Compared to natural sciences, the objects and structures studied by social science are socially constructed. Another difference is that empirical research in social science focuses on open rather than closed systems (Sayer, 2000). Saunders *et al.* (2007, p. 115) elaborates: *"we will only be able to understand what is going on in the social world if we understand the social structures that have given rise to the phenomena that we are trying to understand … our knowledge of reality is a result of social conditioning and cannot be understood independently of the social actors involved in the knowledge derivation process."* In light of this, social phenomena often have a limited durability and *"we cannot expect social science's descriptions to remain stable or unproblematic across time and space"* (Sayer, 2000, p. 13). Hence, objects and structures studied by social science can be considered to be both time and space dependent (Zachariadis *et al.*, 2013). It is therefore important to consider the existence of contextual factors for generalization of theory and *"the role of the empirical qualitative methods is to uncover these conditions and distinguish them from the necessary (internal) aspects of objects and structures"* (ibid, p. 864).

3.1.4 Causation and implications on research design

A particular feature of critical realism, for example in comparison with positivism, lies in the analysis of causation. Critical realism rejects the model of cause-effect relationship and causation cannot be proved by finding regularities in collected data: *"What causes something to happen has nothing to do with the number of times we have observed it happening"* (Sayer, 2000, p. 14). In the open systems of the social world, understanding causal powers instead builds on identifying and

understanding mechanisms and their outcomes as well as the specific spatio-temporal contexts. Sayer (2000, p. 23) explains*: "a realist approach assumes open systems and a generative model of causation in which the outcomes of the activation of mechanisms … always depends on specific contexts."* With this in mind, there is little value in conducting repeat studies aiming for universal theories. Instead, critical realists recommend qualitative research methods for data collection and analysis to help explain causal mechanisms and understand the meaning of the particular context. Mingers *et al.* (2013), for example, argues that qualitative methods such as interviews and case studies are superior to quantitative methods in regards of describing phenomena, developing propositions and identifying interactions between complex mechanisms. Similarly, Zachariadis *et al.*, 2013 (p. 857) argue that qualitative methods can help to develop "*more valid explanations or theories that approximate the intransitive domain with more probabilistic accuracy"*.

In the process of conducting qualitative research, it is imperative to reiterate that our access to the external reality is fallible and relies on our theoretical and perceptual lenses. Our observations are thus shaped by our prior knowledge of the external reality and embedded in the language used to express what we know (Hanson, 1958; Mingers *et al.*, 2013; Volkoff and Strong, 2013). Hence, as argued by Alvesson and Kärreman (2011), it is plausible that different researchers could end up with different results even if they conducted similar research with same purpose and similar data. To address this issue, Zachariadis *et al.* (2013) underlines the importance of using and triangulating between multiple sources of data. Alvesson and Kärreman (2011, pp. 74-75) also recommend researchers to engage in reflexivity by *"using various theoretical perspectives and metaphors; listening to the alternative voices of research subjects; imagining multiple reader groups; considering different political interests and research purposes … working with co-researchers using another background or theoretical framework; and thus increasing the chances to be challenged when encountering empirical material".*

3.2 The overall research structure and design

The purpose and research questions in this dissertation are addressed through a pilot study followed by three separate but connected studies. The pilot study, which is detailed in section 3.2.1, included a preliminary literature review conducted during November and December, 2010, and an interview study which was conducted during February and March, 2011. The pilot

study helped to understand and streamline the terminology used by practitioners and researchers. The pilot also helped to understand and frame issues and gaps identified in industry and in academic literature.

Following the pilot study, a systematic literature review was conducted. The systematic review brought several insights. One insight was that most empirical research studies have used the survey study and focused on the dyadic relationships. The review thus indicated a lack of qualitative research and a lack of in-depth understanding how companies address information sharing in multi-tier supply chains. Based on these findings, we considered and compared different research methods that could be useful to further investigate a complex phenomenon such as information sharing while expanding the unit of analysis beyond the dyads. Based on recommendations in literature, we chose to conduct a single, embedded case study. Considering primarily the companies involved in the pilot study, we eventually selected one of the companies, *The Absolut Company*, who had worked systematically for 30 years to tailor information sharing with their suppliers and customers. At one time, the company had also implemented multi-tier information sharing but, for various reasons, that project had been closed down. Moreover, they were currently dealing with issues related to demand uncertainty that multi-tier information sharing potentially could help to resolve. The exploratory case study was planned and thereafter carried out in 2012 in collaboration with *The Absolut Company*.

The two first studies, i.e. the systematic literature review and the case study, provided input to framing and designing the third and final study included in this dissertation. The case study had revealed a lack of multi-tier information sharing and potential barriers to moving beyond the dyads. Against this background, the aim was at first to conduct a multiple-case study with companies that had implemented multi-tier information sharing. A multiple-case study was perceived as useful to get in-depth understanding of why and in what contexts companies engage in multi-tier information sharing, and how they overcome the various challenges. We searched for such cases for a period of three years, between 2010 and 2013, and followed up on every lead that could potentially represent a relevant case. Despite the efforts, every lead came to a dead end: either the companies had looked in to the opportunities but had abandoned the project in an early phase due to lack of interest from the involved partners; or companies had attempted to implement but not succeeded due to a number of challenges; or they had implemented but later

closed down the project due to the low ratio between gained benefits and invested resources. Investigating the cases where companies had closed down the projects was also considered; however the involved companies were not willing to participate in such a research project. In light of these efforts, we eventually decided to look in to other options including other research methods. That is when we considered the Delphi study and determined that it could be useful for carrying the research study forward.

The Delphi study can be useful for gaining insights to a complex phenomenon such as multi-tier information sharing in supply chains. The Delphi study allows the researcher to move beyond the isolated cases, and acquire knowledge shared by a panel of international experts. The panelists provide input in several iterative rounds with the purpose to reach consensus. Conducting the Delphi study also provided a great opportunity to reach out to both researchers, consultants and supply chain managers and allowed us to continue the search for a case of multi-tier information sharing. The Delphi study was planned and designed between October and December, 2013, and was thereafter conducted between January and June, 2014. The Delphi study enabled collection and analysis of both commentary input and quantitative data. In combination with the case study, it was possible to merge qualitative and quantitative data collection and analysis to acquire better understanding of the researched phenomenon. The research design applied in this dissertation thus resembles a mixed-method approach (Creswell *et al.*, 2003).

All in all, the three studies were reported in a total of five research papers. The systematic literature review and the case study were initially reported in a licentiate thesis (Kembro, 2012) and thereafter developed into three papers (i, ii, iii). The findings from the Delphi study are reported in two papers (iv, v). The connection between the studies and the related papers are highlighted in Figure 5. While the planning and data collection of the studies resembled a linear process, the data analysis and presentation of results could better be described as an iterative one. As part of conference and journal submissions, the different papers have been subjected to multiple peer reviews and the collected data has therefore been analyzed several times, viewing the data sets from different angles and perspectives by applying different theories and involving researchers with different backgrounds.

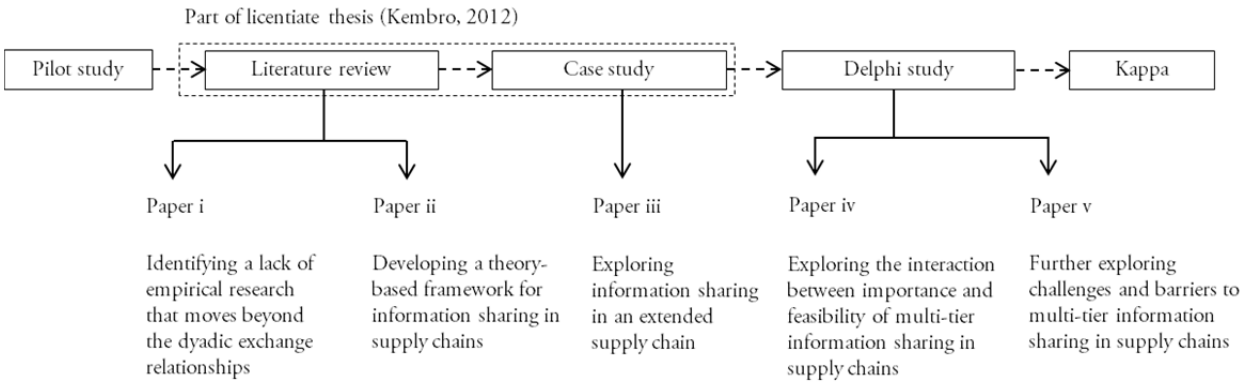

Figure 5 - Development of the three studies and Kappa through time

As highlighted in Figure 5, the two empirical studies are of an exploratory nature. Exploratory research can be useful when there is little or no knowledge of the phenomenon under investigation. It can also be used to look at a phenomenon from a new theoretical perspective with the purpose to increase our understanding. Exploration is a purposive and systematic undertaking leading to description and understanding of a phenomenon. The outcome of exploration is the generation of inductively derived theories about the phenomenon (Stebbins, 2001; Yin, 2014). It could also be argued that the case study and the Delphi study go beyond exploratory research and attempts to further explore and explain the phenomenon by providing additional insights and details through extensive data collection and analysis. Hence, part of the research can be characterized as descriptive rather than merely exploratory. The development of theory in this dissertation is illustrated by the development of a framework for analyzing multi-tier information sharing in supply chains. The developed framework is presented in chapter 5. Next, the methodology of each of the three studies are presented one-by-one.

3.2.1 Pilot study

The aim of the interview study was to explore what information is shared between supply chain partners. Qualitative research and particularly in-depth interviews are useful to enable the researcher to get a thorough understanding of the respondents' world (Davis and Mentzer, 2006). The pilot study (see Kembro and Näslund, 2011) was useful to get the practitioners perspective which, together with preliminary literature reviews, helped to better understand the investigated phenomenon and to identify potential problems in industry and frame the purpose and research questions of the dissertation.

The unit of analysis in the interview study was inter-organizational information exchange between focal company and supplier; focal company and customer; as well as across multiple supply chain tiers. Companies were selected with the aim to include a variety of industries such as automotive, grocery, packaging, mining, construction, processing, fluid handling and consumer goods, see Table 6. Key informants were senior managers with at least ten years of experience of logistics and supply chain management. The interviews were carried out on-site for each company during February and March 2011 and each interview was semi-structured and lasted between one and three hours. The interview guide is attached in Appendix i. The interviews were recorded and transcribed after which each transcript was summarized and sent back to the respondents to be confirmed.

Table 6 - Overview of key informants for the pilot study.

Firm	Industry	Interviewee's position
1	Automotive	Supply Chain Manager
2	Consumer goods	Supply Chain Manager
3	Consumer goods	Process Manager
4	Fluid handling	Supply Chain Manager
5	Grocery	Business Process Developer
6	Mining	Purchasing and Logistics Manager
7	Mining	Supply Chain Manager
8	Construction	Business Process Developer
9	Packaging	Logistics Manager
10	Processing	Logistics Manager

3.2.2 Study 1: Systematic literature review

Literature reviews can be useful for advancing research (Mentzer and Kahn, 1995) by, for instance, mapping research developments in order to formulate research agendas (e.g. Carter and Ellram, 1998; Giunipero *et al.*, 2008) and pulling results from different research studies together in order to develop theory (e.g. Choi *et al.*, 2001; Carter and Rogers, 2008). A literature review should build on rigorous application, be independently replicable and ensure a substantial theoretical contribution in terms of scientific and pragmatic usefulness (Mulrow, 1987). Considering these requirements, the systematic literature review has been proposed and developed to provide structure, increase objectivity and reduce bias in reviewing relevant literature (Mulrow, 1987; Tranfield *et al.*, 2003; Briner *et al.*, 2009; Denyer and Tranfield; 2009; Short, 2009).

The systematic literature review that was conducted as part of this dissertation thesis builds on the guidelines provided by, for example, Tranfield *et al.* (2003). The review builds on previous literature reviews in the field (cf. Sahin and Robinson, 2002; Huang *et al.*, 2003) with the purpose to identify contemporary research reported in peer-reviewed articles which are published in ten recognized journals between 2000 and 2012. A list of considered journals is included in Table 7.

Table 7 - Journals included in the systematic literature review.

Journal
Decision Science
International Journal of Operations & Production Management
International Journal of Physical Distribution & Logistics Management
International Journal of Production Economics
Journal of Business Logistics
Journal of Management Information Systems
Journal of Operations Management
Journal of Supply Chain Management
Management Information Systems Quarterly
Supply Chain Management: An International Journal

Journal selection was guided by using the following criteria: i) journals that include empirical research articles and are well represented in the fields of supply chain management, operations management, operations research and management information systems; ii) journals that we have found to be well represented in previous literature reviews related to information sharing in supply chains; and iii) the ranking of journals in related fields as listed in the Harzing Journal Quality List (www.harzing.com/jql.htm).

The search was facilitated through the use of two databases: Thomson Reuters (formerly ISI) Web of Knowledge and SciVerse Scopus. Based on a prior scoping study, a combination of the following keywords was used to identify relevant literature: [data, information, knowledge]; [flow, shar*, transfer, exchange]; [supply chain, supply network, supply channel, value chain, logistics]. An example of a combination, using the Boolean logical operator "AND", could thus be: "information" AND "exchange" AND "supply chain". From an initial set of 477 articles, 26 duplicates were removed. Thereafter, the abstract of each paper was reviewed considering the following inclusion criteria: i) paper must be written in English; ii) paper must demonstrate inter-organizational information sharing in supply chains as the clear focus/objective of the research; and iii) paper applies an empirical research method as described by Wacker (1998). Papers focusing on intra-organizational information sharing and/or applying analytical research methods were thus excluded from the sample, leaving a sample of 107 papers. The full-text version of these papers was then examined, using the same inclusion/exclusion criteria, resulting in another 25 papers being excluded. The final sample included a total of 82 papers.

A data extraction sheet was used to structure the data collection and analysis of each paper, see Table 8. The data extraction sheet was devised corresponding to the columns in the Excel database and included general publication details (title, author, journal and year of publication) and main elements relevant for this dissertation, including: definition of information sharing, purpose and key study findings, aspects of information sharing, unit of analysis and unit of data collection as well as applied research method and theoretical perspectives.

Table 8 - Categories and classification scheme used for extracting data.

Category	Description
Title	Complete title of paper
Author(s)	Complete names of authors
Journal	Journal in which the paper has been published
Year	Year of publication
Definitions	Definition of the term "information sharing"
Purpose	Brief outline of the purpose of the study
Findings	A summary of the key findings
Aspects	Description of information sharing aspects being investigated
Unit of analysis	The part of the supply chain that was the focus of the research
Unit of data collection	The part of the supply chain where data was collected
Research method	Description of the applied empirical research method(s)
Theories	A list of all theoretical lenses being used to analyze the collected data

3.2.3 Study 2: Exploring through a case study

Several researchers suggest that the case study is an appropriate research method for exploring phenomena that we have limited understanding about (Benbasat *et al.*, 1987; Cassell and Symon, 2004; Voss *et al.*, 2012; Yin, 2014). The case study is also preferred to provide depth and insight into a studied phenomenon when the study focuses on a contemporary event with little control of observed behaviors (Ellram; 1996).

In this dissertation, a single, embedded case design was used with the purpose to explore information sharing and potential barriers in an extended supply chain including the focal company, suppliers, suppliers' suppliers, customers and customers' customers. The embedded cases refer to the interconnected dyadic relationships between, for example, the first tier suppliers and the focal company. The case study was conducted in collaboration with *The Absolut Company* (TAC) who systematically, for nearly three decades, developed information sharing with their supply chain partners. The case study enabled collecting data from multiple firms (cf. Easton, 2010) making it possible to gather multiple perspectives and views on information sharing in the extended supply chain. Figure 6 depicts the studied supply chain. Despite the fact that data was not directly collected from second-tier suppliers and second-tier customers, interviews with focal

company, first-tier suppliers and first-tier customers provided insights into the second-tier suppliers' and customers' operations and relations with other supply chain partners.

Given the long and systematic work to improve information sharing in the supply chain, the network of TAC and their upstream and downstream partners could be considered to represent a critical case (Patton, 2002; Yin, 2014). Further, gaining access to and conducting a research study with multiple companies representing three supply chain tiers is difficult and, perhaps for that reason, scarce in previous research on the topic of information sharing in supply chains. The case thus provides a unique opportunity to investigate information sharing across multiple supply chain tiers. The case study also applied stratified sampling, i.e. samples within the sample, by including six component suppliers and two purposefully selected markets. Thereby, it was possible to capture both variations and a common core during the data analysis. The two markets represent, on the one hand a "common" market situation, and on the other hand an "extreme" market situation in the portfolio of TAC. The UK market represents the common market situation, including one market company selling on to wholesalers who then distribute the product through an extensive retail network. This part of the supply chain typically involves many marketing campaigns and ad-hoc promotional activities which inject demand uncertainty and increase the bullwhip effect as orders are passed on upstream in the supply chain. The Swedish market represents the extreme market situation. Sweden represents a unique, monopolistic market situation. There is only one primary customer and campaigns and promotions are restricted by law.

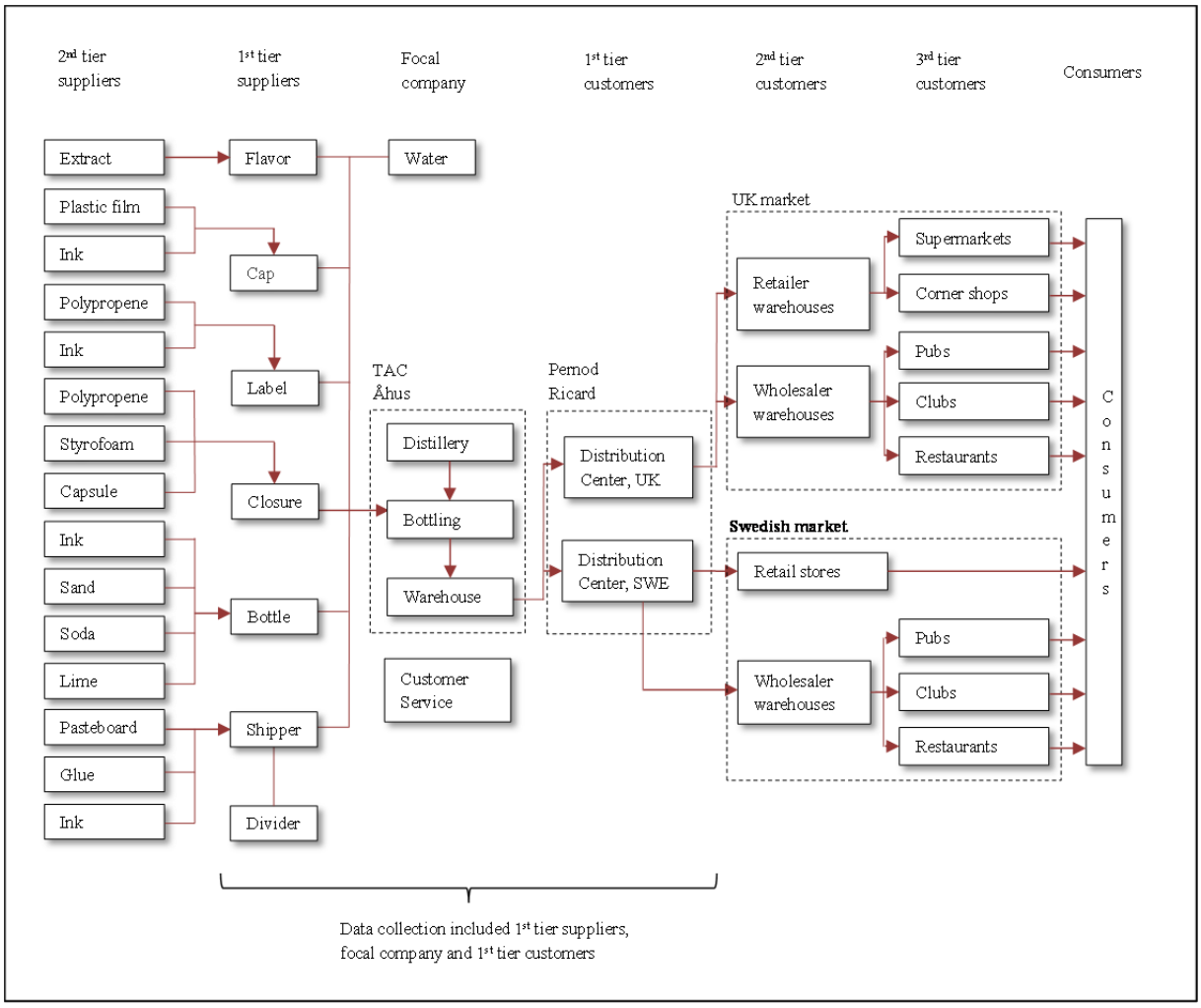

Figure 6 - The Absolut Company supply chain: actors and material flows.

Data collection included visits to TAC's facilities, company presentations, semi-structured interviews as well as review of documents including process flow charts, past and current information sharing initiatives and related performance improvements. TAC and their supply chain partners thereafter recommended staff with relevant insights to the inter-organizational flows of material and information. Interviewees were contacted by email and telephone. Some companies chose to include more than one respondent to be able to cover all aspects of the interview. All interviewees received a background to the project and the interview guide beforehand. A total of 14 interviews were conducted as part of the case study: six of them with TAC; six with TAC's suppliers and two with TAC's customers, see Table 9. Each interview lasted for one hour and was recorded and thereafter transcribed. The interview guide is included in

Appendix ii. A summary of the transcription was sent to respective company to allow the interviewees to read through and confirm that the answers had been correctly understood. Thereby, the truth-value of the study was improved (Da Mota Pedrosa *et al.*, 2012). Once the summaries had been confirmed by the respective interviewees, a final workshop was conducted at TAC's site in Åhus to discuss the findings and conclusions. The workshop included two researchers and the Director Supply Chain Management and Chief Procurement from TAC.

The collected data was analyzed through the lens of interdependence theory (Thompson, 1967) following the ladder of analytical abstraction (Carney, 1990; Miles and Huberman, 1994). First, the data was coded using a combination of codes collected from literature (e.g. unit of analysis, organizational level, and types of interdependence) and open coding, i.e. codes that emerged from the analysis of the collected data (Ellram, 1996). An example of coding that emerged during the analysis includes the potential barriers related to misinterpreted and incomplete information, both contributing to the lack of information quality. In the second step, referred to as pattern coding (Miles and Huberman, 1994) or axial coding (Ellram, 1996), the analysis focused on identifying trends and themes in the data set. One theme that emerged was the partners' perceived difficulty to make use of information shared across multiple tiers, and different reasons for this increased difficulty including the lack of regular meetings and formal contracts in place. In the third and final step, the findings from the study were discussed and reflected upon with key representatives from *The Absolut Company*.

Table 9 - Overview of included companies and conducted interviews.

Tier	Product	Company	Country	Years as TAC partner	Staff	Turnover	Interviewees (number of interviews given in brackets)
1st tier customer (distributor)	Absolut Citron	Pernod Ricard SWE	Sweden	5	18,777 (total Pernod Ricard)	70 billion SEK (total Pernod Ricard)	Supply Chain Manager (1)
1st tier customer (distributor)	Absolut Citron	Pernod Ricard UK	UK				Operations Director (1)
Focal company (customer service)	Absolut Citron	TAC	Sweden		680+ (total The Absolut Company)	11.4 million 9-liter cases of Absolut Vodka (all articles)	Regional Manager Sweden, Regional Manager UK (1)
Focal company (production)	Absolut Citron	TAC	Sweden				Director Operations (1), Director Supply Chain Management (1), Chief Procurement (1), Production Manager (1), Quality Engineer (1)
1st tier supplier	Glass bottle	BM	Sweden	>25	500	1 billion SEK	Sales Manager, Supply Chain Manager, Order administrator (1)
1st tier supplier	Closure	CS	Sweden	10	55	100 million SEK	Managing Director (1)
1st tier supplier	Label	LS	Sweden	10	87	180 million SEK	Key Account Manager, Chief Procurement (1)
1st tier supplier	Packaging (Shipper + divider)	PM	Sweden	>25	1400	4.8 billion SEK	Key Account Manager (1)
1st tier supplier	Cap (Sleeve)	CM	UK	10	1000	1.2 billion SEK	Sales Manager (1)
1st tier supplier	Flavour	FS	Sweden	>25	50	80 million SEK	Key Account Manager (1)
Total							**14 interviews**

3.2.4 Study 3: Exploring through a Delphi study

The Delphi study is a systematic group communication process where invited experts anonymously provide input on a complex problem through multiple rounds of questionnaires (Dalkey and Helmer, 1963; Klassen and Whybark, 1994; Linstone and Turoff, 2002). The value of using the Delphi study for exploratory theory building has been demonstrated through its application in various research areas (Akkermans *et al.*, 2003; Melnyk *et al.*, 2009). The Delphi study has previously been used to explore factors influencing decision-making on specific issues, topics or problem areas in supply chain management, see Table 10. Examples include identifying barriers to the management of international operations (Klassen and Whybark, 1994), determining factors affecting location decisions in international operations (MacCarthy and Atthirawong, 2003), and identifying barriers and drivers to purchasing and supply management sustainability (Giunipero *et al.*, 2012).

Table 10 - Overview of previous applications of Delphi studies in supply chain management.

Authors	Years	Journal	Topic
Klassen & Whybark	1994	JOM	Barriers to the management of international operations
Malhotra *et al.*	1994	DS	Important strategic and tactical manufacturing issues
Akkermans *et al.*	1999	IJOPM	Virtuous and vicious cycles on the road towards international SCM
Akkermans *et al.*	2003	EJOR	The impact of ERP on SCM
MacCarthy & Atthirawong	2003	IJOPM	Factors affecting location decisions in international operations
Lummus *et al.*	2005	IJPR	Important characteristics of flexible supply chains
Ogden *et al.*	2005	JSCM	Supply management strategies for the future
Hameri & Hintsa	2009	IJPDLM	Drivers of change for cross-border supply chains
Melnyk *et al.*	2009	IJPR	Mapping the future of SCM
Giunipero *et al.*	2012	JPSM	Purchasing and supply management sustainability: drivers and barriers
Huscroft *et al.*	2013	IJLM	Reverse logistics
Mason & Nair	2013	IJLM	Supply-side strategic flexibility capabilities in container liner shipping

In the Delphi study conducted as part of this dissertation, a total of 32 SCM executives, 36 consultants and 30 researchers were invited with the aim to capture both the inside and outside perspective of the researched phenomenon. The inside perspective was thus captured by involving SCM executives who work inside companies that engage in information sharing. SCM executives with at least ten years of experience from global supply chain management representing a wide range of industries were invited by referring to professional networks. The outside perspective was represented by consultants and academics. Senior consultants were identified based on top-ten listings of global, European and Nordic consulting firms. Finally, researchers were invited considering publications relevant to the topic of the study. Well in line with Delphi guidelines, a total of 29 experts agreed to participate in the Delphi study. The panel was represented by 12 SCM executives, 12 consultants and 5 researchers. All panel members participated in the entire study eliminating the potential issue of non-response bias (Okoli and Pawlowski, 2004).

The Delphi study was planned between October and December 2013 and thereafter conducted over three rounds between January and June 2014. An overview of the Delphi study process is presented in Table 11. Each round included a questionnaire which was designed and tested through a pilot study before being sent out to the respondents. The pilots were conducted with a panel represented by three practitioners and three researchers to test the medium and the questions as well as to improve the layout of the questionnaire and quality of communication in the attached letter. The invitation letter and the three questionnaires are included in Appendix iii.

In the first round, the topic was explored through a set of open-ended questions without imposing bias or leading the respondents in any particular direction (cf. Okoli and Pawlowski, 2004; Lummus *et al.*, 2005). The first round resulted in commentary input corresponding to a total of 15,300 words which was then subject to a content analysis in order to identify keywords and themes. Identified themes included, for example, a long list of challenges and potential barriers related to involving multiple supply chain partners as well as numerous contextual factors that should be considered for multi-tier information sharing. The findings from the first round were then used as input for round two. In the second round, the respondents were able to consider and comment on the findings from the first round with the aim to reach an understanding and possible consensus among the respondents. To make it easy for the respondents, the questionnaire was sent both as a Word document and as a link to

SurveyMonkey. Based on the answers, it was possible to identify consensus regarding certain topics. Input from the two first rounds was then used for the third round where the respondents were asked to provide quantitative responses. The respondents' opinions regarding various challenges and potential barriers as well as contextual factors were assessed through seven-point scales. In a complementing round, outlying responses were further explored by allowing the respondents to elaborate and reconsider their answers in comparison to the general agreement within the panel.

Table 11 - Overview of the Delphi study process.

Step	Description	Time period	Comment
1	Define objective and formulate RQ	20 Oct - 10 Dec 2013	RQ based on: (i) previous research, (ii) discussions within research group, and (iii) discussions with SCM executives and consultants.
2	Setting up panel: Establish criteria and identify experts	10 Dec 2013 – 10 Jan 2014	Panel included researchers (with relevant publications), consultants (with at least ten years of international experience in IT and/or SCM) and SCM executives (with at least ten years of experience in global SCM).
3	First round questionnaire	10 Jan - 20 Feb 2014	Pilot conducted with three practitioners and three researchers; First round sent on 22 January. Two reminders sent out (one week and one day before deadline).
	Analysis	20 Feb - 10 March	Content analysis resulting in a list of keywords, emerging themes and unique insights.
4	Second round questionnaire	10 March - 15 April	Pilot conducted following the same process as in round one. Second round sent on 28 March, giving the experts two and a half weeks. Two reminders were sent.
	Analysis	15 - 25 April	Consensus, similarities and differences in opinions were identified regarding the different themes and insights. By comparing with individual answers from the first round, the list of contextual factors as well as challenges and potential barriers was updated and carried forward to the third round.
5	Third round questionnaire	25 April - 28 May	Pilot conducted following same process as in first and second round. Third round sent on 9 May. Two reminders were sent.
	Analysis	28 May - 5 June	Identified common agreements as well as a limited number of outlying responses.
6	Complementing round	5 - 10 June	Outlying responses explored in a complementing round where respondents were given another opportunity to elaborate and reconsider their answers.
	Final analysis	10 - 30 June	The final analysis included both statistical analysis of quantitative data and content analysis of qualitative input.

3.3 Research quality

Research quality can, along the lines of Zachariadis *et al.* (2013), be related to the extent that the findings and implications reported in this dissertation approximate the intransitive domain. There are two important considerations for increasing research quality and developing more valid theories: i) engage in different types of triangulation; and ii) consider the existence of contextual factors for generalization of theory.

The purpose of triangulation is to verify and validate qualitative analysis. Four types of triangulation are important to avoid the pitfalls of relying on singular methods and sources, lone analysts and single-perspective theories (Patton, 1999), see Table 12. Next, these four types are discussed and described how they were addressed in this dissertation. First, methods triangulation was carried out by conducting an in-depth case study followed by an extensive Delphi study. By employing both the case study method and the Delphi study method it was possible to compare and confirm the consistency of findings from two different methods. Second, within each method, sources were triangulated by using on-site visits, interviews, company presentations, workshops as well as questionnaires with both commentary input and quantitative assessment using seven-point Likert scales. Interviewees included in the case study represent different functions within the purposefully selected companies. Further, the companies represent three different tiers of the studied supply chain which made it possible to gather multiple views and compare the perspectives of various companies and interviewees. In the Delphi study, respondents representing researchers, consultants and SCM executives were selected to capture both inside and outside perspective of the researched phenomenon. The multitude of data sources thus helped to get deeper insight and better understanding of information sharing in supply chains. Also, considering the combination and synergy of using qualitative and quantitative methods for collecting and analyzing data, this dissertation has the characteristics of mixed-method research (Creswell *et al.*, 2003). The merging of data sets from, for example, commentary input and seven-point Likert scales helped to better understand the researched phenomenon by provide both a depth as well as concrete numbers to compare and contrast different factors.

Third, analyst triangulation was done by involving multiple analysts to review the findings of the empirical studies. Researchers with different research backgrounds such as logistics, purchasing

and contracting, production and operations management as well as supply chain management were involved in the different studies to allow for additional perspectives and insights to emerge during data analysis. Fourth, theory triangulation was partly addressed by applying interdependence theory to analyze the data collected in the case study and by using contingency theory to interpret part of the data collected in the Delphi study. However, different theories were not used to analyze the same data. The theoretical perspectives were also reflected upon through the systematic literature review where a theory-based framework was developed for analyzing and understanding the researched phenomenon.

Table 12 - Overview of how different types of triangulation were addressed.

Type of triangulation	Description of how it was addressed in this dissertation
Methods triangulation	Employing a case study and a Delphi study made it possible to compare and confirm the consistency of findings from using two different methods.
Data source triangulation	Sources were triangulated by using on-site visits, interviews, company presentations, workshops as well as questionnaires with both commentary input and quantitative assessment using seven-point Likert scales. Interviewees for the case study were selected from different functions within companies representing three different supply chain tiers. Respondents in the Delphi study represented researchers, consultants and SCM executives to capture both inside and outside perspective.
Analyst triangulation	Multiple researchers with different research backgrounds such as logistics, purchasing and contracting, production and operations management as well as supply chain management were involved in the different studies to allow for additional perspectives and insights to emerge during data analysis.
Theory triangulation	Theory triangulation was partly addressed by applying interdependence theory to analyze the data collected in the case study and by using contingency theory to interpret part of the data collected in the Delphi study. Various theoretical perspectives were also reflected upon through the systematic literature review where a theory-based framework was developed for analyzing and understanding the researched phenomenon.

Acknowledging that social structures are time and space dependent, the two empirical studies set out to unearth contextual factors that should be considered for information sharing in supply chains. The case study represents a single supply chain involving multiple producing and distributing companies. Generalizing beyond the single case should be done with great care.

However, by using the perspective of interdependence theory, the analysis offers important insights how companies engage in information sharing based on the type and intensity of interdependence between supply chain partners. Building on the case study findings, the Delphi study seeks to further explore the existence and impact of various contextual factors. For example, the study explores the interaction between importance and feasibility of multi-tier information sharing. The Delphi study moves beyond the particular case context by involving multiple supply chain experts with extensive experience from research, consulting and managing global supply chain operations. Considering the accumulated experience in the expert panel, it is unlikely that another panel would lead to significantly different results (Ogden *et al.*, 2005).

Rigor of the qualitative research studies was also improved by addressing the criteria for trustworthiness put forward by Halldorson and Aastrup (2003, pp. 327-328), see Table 13.

Table 13 - Overview of research quality criteria (based on Halldorson and Aastrup, 2003).

Criterion	Definition	How the criterion is addressed in this dissertation
Credibility	Degree of match between the respondent constructions and researchers representation of these	Case study: interviewees reviewed and revised summaries of interviews; findings were also discussed with key informants from TAC during a workshop. Delphi study: respondents were given multiple opportunities to consider other respondents' answers, change their input and add new insights.
Transferability	Extent to which the study is able to make general claims about the world	Case study: various types of sampling were employed to acquire insights from various companies and industries as well as different kinds of markets. Delphi study: moved beyond the isolated cases and particular contexts to gather insights from a large group of experts with extensive experience from a range of supply chain contexts.
Dependability	Stability of data over time	Case study: all interviews were recorded and transcribed and summarized. Delphi study: research protocols were set up to keep track of all events and findings over time. Both studies: all findings were inserted to Word and Excel documents, sorting information in relevant columns.
Confirmability	The findings represent the results of the inquiry and not the researcher's biases	Both studies: all findings and interpretations were documented and can be traced throughout the research studies. To address the inevitable issue of researcher bias, all data was considered by at least one other researcher.

First, credibility which is described as the *"degree of match between the respondent constructions and researchers representation of these"* was addressed in various ways. In the case study, the respondents were asked to read through summaries of the interviews and allowed to comment and make changes in the documents to ensure that the researcher had understood correctly. The findings were also discussed with key informants from TAC during a workshop. In the Delphi study, the respondents were given multiple opportunities to consider other respondents' answers, change their input and add new insights. The findings from each round were used as input for the next round so the respondents had several chances to correct in case they disagreed with any information.

Second, transferability which is defined as the *"extent to which the study is able to make general claims about the world"* was also addressed in both the case study and in the Delphi study. In the case study, various types of sampling were employed to acquire insights from various companies and industries as well as different kinds of markets. Nonetheless, the context of the studied supply chain is important to consider and generalization beyond the case context should be done with care. As discussed by Halldorson and Aastrup (2003) both time and present a constraint to generalizing findings and hence the aim for qualitative researchers (and critical realists) should be to contextualize rather than to generalize. With this in mind, the Delphi study provided an opportunity to move beyond the isolated cases and particular contexts and gather insights from a large group of experts with extensive experience from a wide range of supply chain contexts including, for instance, information technology, telecom and fast moving consumer goods. As previously discussed, it is unlikely that another panel would come to significantly different results than the one set up for the purpose of this dissertation.

The third criteria, dependability is conventionally referred to as reliability and *"concerns stability of data over time"*. Halldorson and Aastrup (2003) underline the importance of being able to replicate the various data collection and analysis steps conducted in a study. This criterion was addressed by meticulously planning, designing and carrying out the empirical research studies. All interviews were recorded and transcribed and summarized. In parallel, research protocols were set up to keep track of all events and findings over time. All findings were inserted to Word and Excel documents by sorting information in relevant columns. Finally, confirmability signifies that *"the findings represent the results of the inquiry and not the researcher's biases"*. This criterion

highlights the importance of the reader being able to understand the logical link between the conducted study and the reported findings. In other words, the findings and interpretations should be possible to track backwards to their original sources. In this dissertation, all findings and interpretations were documented and can be traced throughout the research studies. Of course, from a critical realist perspective, there will always be a certain degree of researcher bias based on the researcher's experience, perceptual and theoretical perspectives. In order to reduce the influence of researcher bias, all data was considered by at least one other researcher.

4. Summary of appended papers

The purpose of this dissertation is to investigate information sharing in multi-tier supply chains, as well as to explore opportunities and challenges to sharing information beyond the dyadic relationships. The following five, appended papers each contribute to this purpose by answering one or more of the research questions.

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

ii. Kembro, J., Selviaridis, K., and Näslund, D. (2014). "Theoretical perspectives on information sharing in supply chains: a systematic literature review and conceptual framework." *Supply Chain Management: An International Journal* 19(5/6):609-625.

iii. Kembro, J. and Selviaridis, K. "Exploring information sharing in the extended supply chain: An interdependence perspective." Forthcoming in *Supply Chain Management: An International Journal* 20(4).

iv. Kembro, J., Olhager, J. and Näslund, D. "Importance and feasibility of multi-tier information sharing: findings from a Delphi study." Presented as full paper at the tenth European Research Seminar, 2015. To be submitted.

v. Kembro, J., Näslund, D. and Olhager, J. "Exploring challenges and barriers to multi-tier information sharing in supply chains." To be submitted.

In the following sections, the papers are presented one by one, outlining the respective purpose, results and implications. In chapter 5, the papers are thereafter discussed altogether, resulting in a framework for multi-tier information sharing.

4.1 Paper i

Following the pilot study, paper i represents the starting point for this dissertation thesis. The purpose of the research study reported in paper i was to investigate what empirical evidence exists of multi-tier information sharing and related benefits. The investigation builds on a systematic literature review (cf. Tranfield *et al.*, 2003) and analysis of a final sample representing 82 empirical papers. These papers were reviewed considering, for example, the applied unit of data

collection, research method and unit of analysis. Table 14 provides an overview of the number of reviewed papers for each combination of unit of data collection and unit of analysis, also detailing the applied research methods. Moving rightwards in the table indicates an increased unit of analysis (dyadic downstream/upstream, limited triadic, triadic, extended downstream/upstream) whereas moving downwards indicates an increased unit of data collection (focal company, dyadic, triadic, extended; i.e. data was collected from one, two, three or more than three companies).

Table 14 - Unit of data collection (UoDC) and research method versus unit of analysis (UoA).

UoDC vs. UoA	Dyad DS	Dyad US	Dyad	Lim. Tri.	Tri.	Ext. DS	Ext. US	Ext.	Total
# Firms	2	2	2	3	3	>3	>3	>3	
Focal company	*8*	*19*	*23*	*9*		*1*			*60*
Survey	5	16	23	5					49
Case study	3	1		4					8
Secondary data		2							2
Interview study						1			1
Dyadic	*1*	*3*	*12*	*2*					*18*
Survey			4						4
Case study	1	3	5	1					10
Secondary data				1					1
Experiment			1						1
Archival research			1						1
Grounded theory			1						1
Triadic				*1*	*1*				*2*
Case study				1	1				2
Extended							*1*	*1*	*2*
Case study							1	1	2
Total	**9**	**22**	**35**	**12**	**1**	**1**	**1**	**1**	**82**

The results reveal, contrary to common belief, a lack of evidence of multi-tier information sharing and related benefits. To clarify, multi-tier information sharing may very well exist and be beneficial; however, based on the systematic literature review, it was not possible to find any empirical papers that provide such evidence.

Based on the findings, a number of implications are outlined. One is that future research ought to move beyond the commonly researched dyads, particularly if we aim to draw conclusions and make recommendations about the extended supply chain. Second, there is a need for streamlining the terminology related to the research area of information sharing in supply chains in order to be able to compare results from different studies. Third, it appears that the survey method is the predominant research method representing 65% of the reviewed papers. It may be that using the survey method to capture the perspective of multiple firms in an extended supply chain is a difficult undertaking (cf. Cassell and Symon, 2004; Li *et al.*, 2012). Hence, other research methods such as the case study should be considered to complement the survey study in future research. Fourth, there is a need to explore a range of aspects of information sharing in supply chains. Particularly, there is a lack of research investigating 'what information to share with whom' in the supply chain. To support such a research study, it could be valuable to consider a range of theoretical perspectives. One growing stream of research on information sharing has applied contingency theory, which suggests adapting information sharing to the particular supply chain context (Kim *et al.*, 2006; Yigitbasioglu, 2010; Caridi *et al.*, 2010; Wong *et al.*, 2012)

4.2 Paper ii

Paper ii is based on the same systematic literature review used for paper i. Paper ii, however, has a different focus and partly builds on a different set of data. The purpose of the second paper was to explore what theoretical lenses have been used to analyze and understand inter-organizational information sharing. The predominant theories are described and discussed how they could be integrated in a conceptual framework to research different aspects of information sharing in supply chains.

We identified 23 different theories that have been used to investigate different aspects of information sharing. By using different theories in a complementary way, it is possible to increase our understanding of information sharing between companies. As an example, considering the

external environment (contingency theory), the relationship context (relational governance theories such as the relational view) and dependence structures (interdependence theory) could be useful to determine what information to share with which supply chain partner. Particularly, when moving beyond dyads, a multiple theory approach may be needed to understand the complex interplay of such contextual factors (Power and Singh, 2007).

The resulting conceptual framework is illustrated in Figure 7. The conceptual framework highlights the importance of tailoring information sharing structures and mechanisms to the context of the transaction and the business relationship. The framework also provides an outline for organizations to formulate their own information sharing strategy. Such a strategy should detail reasons for/against sharing, what to share with whom, how to share, challenges and potential barriers and, finally, the appropriate governance structure. The framework has also been used to position and structure the empirical research studies included in this dissertation thesis. Particularly, paper iii reports the results from the in-depth case study and applies interdependence theory to understand what information is shared with whom in an extended supply chain whereas paper iv is based on a Delphi study and applies contingency theory to explore in what supply chain contexts it may be both valuable and feasible to implement multi-tier information sharing. Paper v is also based on results from the Delphi study and explores challenges and potential barriers involved with multi-tier information sharing.

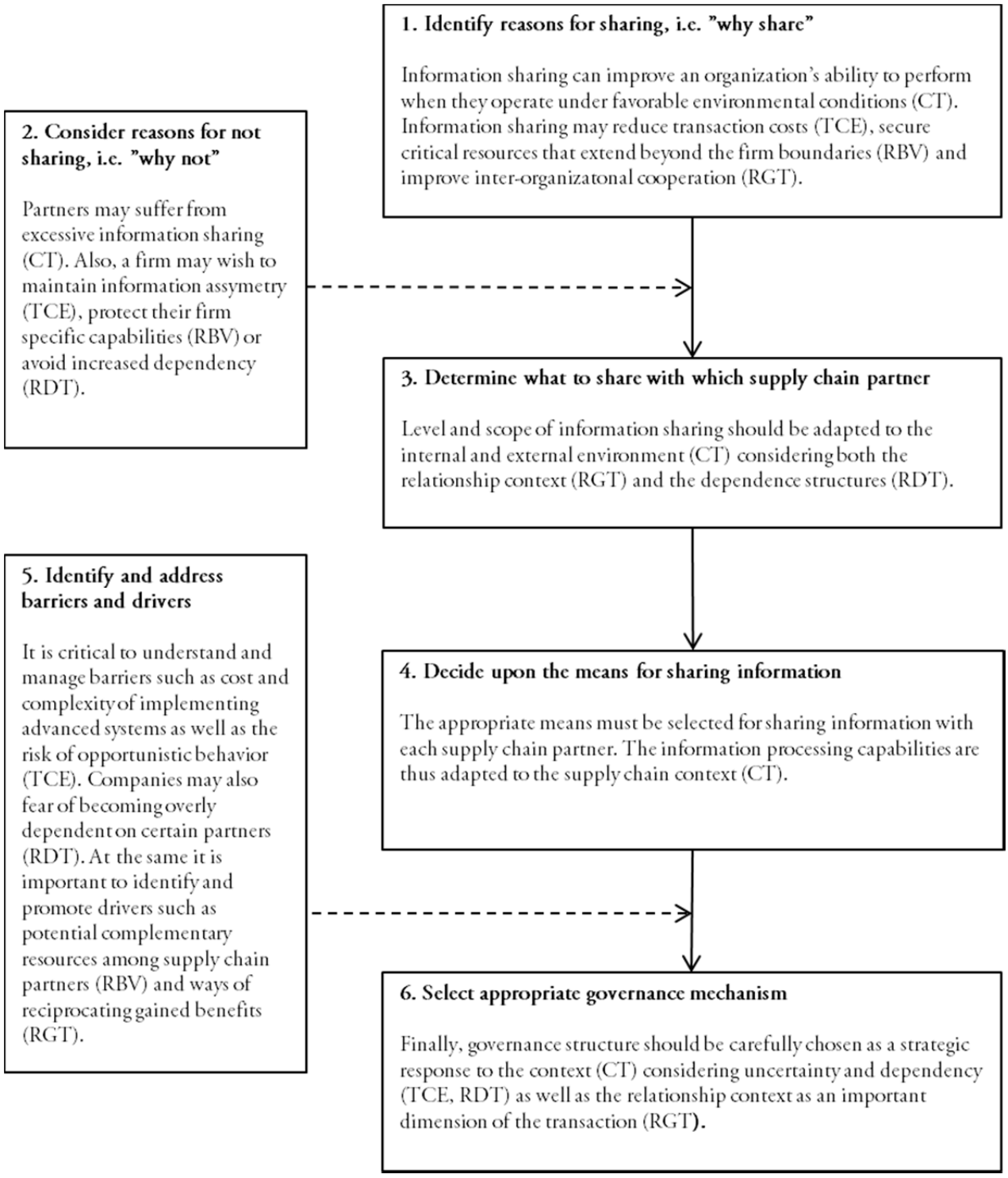

Figure 7 - Conceptual framework of information sharing in supply chains.

Abbreviations: CT=Contingency Theory, TCE=Transaction Cost Economics, RBV=Resource Based View, RGT=Relational Governance Theories, RDT=Resource Dependence Theory

4.3 Paper iii

To address the lack of empirical research moving beyond the dyadic relationships, the purpose of paper iii was to empirically explore information sharing in an extended supply chain. The purpose was addressed through a single, embedded case design applying a range of methods to collect data from firms representing three supply chain tiers (supplier-manufacturer-customer). The collected data is analyzed through the lens of interdependence theory.

The findings in terms of existing dyadic information sharing and perceived benefits are presented in Table 15. Similar to previous empirical research, the findings of this exploratory study indicate that companies focus on dyadic information sharing and refrain from sharing information beyond the dyadic relationships. Further, from the perspective of interdependence theory, it appears that the supply chain actors adapt information sharing to the pooled, serial or reciprocal type of interdependence. Information sharing is, for example, increased with the main upstream and downstream dyadic partners representing unique offerings and high market shares as percentage of total expenditure/sales. Moving beyond the dyads, the interviewees highlight that the partners have no direct link between each other. Without a direct link, partners representing multiple tiers seldom, if ever, meet and discuss business to draw up contracts for enabling and controlling information sharing initiatives. Further, due to the network structure, multi-tier supply chain partners seem to represent low percentage of volume and value in each other's portfolios. The products and components tend to be replaceable and it is likely possible to switch to other partners. These characteristics together indicate a weak, pooled type of interdependence between multi-tier partners (cf. Thompson, 1967; Cox, 2004). Related, the study identifies potential barriers to multi-tier information sharing, including problems related to misinterpreted and/or incomplete information. Challenges and barriers are further explored in paper v.

Table 15 - Details of existing information sharing and perceived benefits.

Organizational level	Companies involved		What information is shared	Benefits of information sharing
Operational level	All dyadic relationships in the supply chain		Order information (order is placed and acknowledged with confirmed delivery times) and changes in production and delivery schedule (intervals change between suppliers depending on volume ordered).	Supporting the daily physical flow of products through the supply chain.
	TAC	BM, PM	Weekly order for the next 7 days, specifying product details including quantity, # pallets, day and time. Twice per day, five days per week partners follow up on the production plan and dispatched goods.	Optimized utilization of assigned capacity.
Tactical level	TAC	All suppliers	Forecast indicating what will be produced the coming four to twelve weeks (intervals change between suppliers depending on volume ordered).	Attempt to predict and match supply with demand in distribution to better synchronize production and logistics capacities.
	TAC	BM	Changes in bottle design (quarterly); detailed information on products and quantities required for the coming three months.	Improved planning of production, reserved capacity and scheduling of labour.
	Pernod Ricard UK	2nd tier customers : major clients	Monthly meetings to discuss promotional activities and upcoming demand in terms of volume for the coming three months (this information is passed on by Pernod Ricard upstream to TAC).	Improved production plans resulting in reduced inventory levels, reduced tied up capital and a mitigated risk of depleted products.
Strategic level	TAC	All suppliers	One-year demand forecast and upcoming design changes; phasing in and out of different products; planned changes in material or supplier base.	Strengthened relationship and increased trust between partners.
	TAC	BM, PM, CS	Additional information on planned future growth and changes in production techniques and/or facilities.	Shared view of the future and potential growth to ensure that sufficient production capacity is available.
	TAC	BM	Five-year plans concerning planned expansion and required investments.	Minimized risk of facing a stock-out in any market.
	2nd tier suppliers	1st tier suppliers (e.g. CS)	Product life cycles; introduction or phase-out of certain product segments; material-availability from each supplier to plan ahead and avoid any shortfalls of raw material or components.	Increased productivity by minimizing risk of break-downs.
	Pernod Ricard UK	2nd tier customers : major clients	One-year joint business plan including details on brands, sizes, quantities, new product introductions and upcoming promotional activities (this information is passed on upstream to TAC)	Shared view of the future and potential growth to ensure that sufficient production capacity is available.

Referring back to *The Absolut Company* and their supply chain partners' concern of high inventory levels, the analysis provides some suggestions how managers could proceed with information sharing in their supply chains. Particularly, it is recommended to tailor information flows according to the intensity of interdependence and demand uncertainty. Intensity of interdependence represents, for example, percentage of each other's portfolios in terms of volume and value, number of alternative buyers and suppliers, switching costs and uniqueness in offerings. Demand uncertainty relates to the possibility to foresee future demand, which can be difficult for example in relation to planned changes such as introducing or phasing out of products, or in relation to marketing campaigns, promotional activities or seasonality. Inspired by the works of Cox (2004), Danese *et al.* (2004) and Godsell *et al.* (2011), a conceptual framework is illustrated in Figure 8. The framework which includes examples from the case study can be used to identify important contexts and key partners to focus on when considering the implementation of multi-tier information sharing.

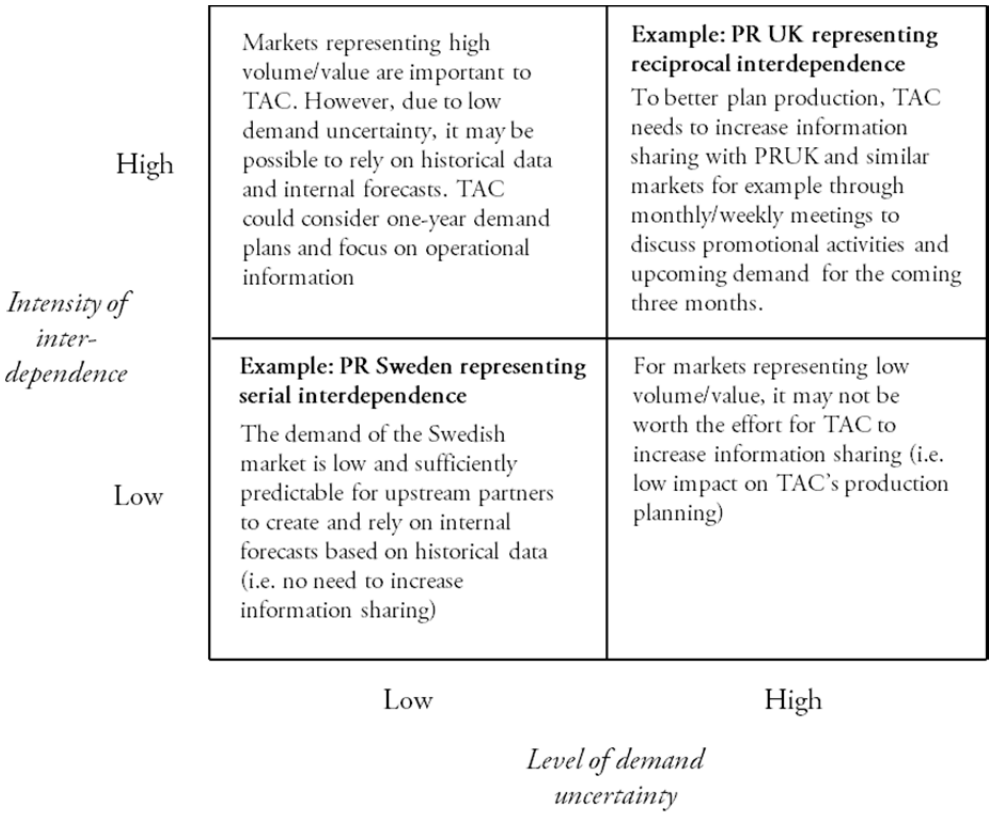

Figure 8 - Framework for identifying important contexts and key partners.

4.4 Paper iv

Building on the findings presented in paper iii, the purpose of paper iv was to move beyond the dyads and explore in which settings multi-tier information sharing is perceived to be relatively more important in terms of potential benefits and relatively more feasible to implement. The purpose was addressed through a Delphi study (see e.g. Klassen and Whybark, 1994; Linstone and Turoff, 2002; Okoli and Pawlowski, 2004; Lummus *et al.*, 2005) including a panel of 29 supply chain experts. The results were analyzed through the theoretical lens of contingency theory.

We identified a total of 16 contextual factors representing: product and market characteristics such as stage of product life cycle, product complexity and demand uncertainty; and supply chain characteristics representing, for example, structural complexity of supply chain, power balance and type of relationship between firms, see Figure 9. We assessed the contextual factors' impact on multi-tier information sharing by contrasting two considerably different settings for each factor (e.g. maturity vs. introduction stage in product life cycle; high vs. low demand uncertainty). Figure 9 is arranged so that the right hand side displays settings that the respondents consider as relatively more important than the settings on the left hand side. Notably, only one contextual factor, collaborative type of company relationships, is perceived as both important and feasible. Contexts considered as important for multi-tier information sharing include product and market aspects such as the introduction stage in the product life cycle, short product life cycle, high product complexity and high demand variability and uncertainty. Meanwhile, contexts considered as relatively more feasible include product and market factors such as the maturity stage in the product life cycle, long product life cycle, low product complexity and low demand uncertainty as well as supply chain factors such as low structural complexity of the supply chain, lean supply chain strategy, low level of information confidentiality and clear power balance.

As highlighted in Figure 9, it appears that the contexts perceived as important are different from those perceived as feasible. In other words, contexts that are considered important are thus perceived as less feasible, and in contexts where it would be possible to implement multi-tier information sharing, it may not be worth the effort. Regarding the latter, one of the panel experts in the Delphi study provides a concrete example: *"I am for example considering a supply chain for a*

particular dairy product, a mature product with stable sales figures and predictable demand variations over the year. However, while it would be highly feasible to implement, I would still argue that the value of multi-tier information sharing in such a supply chain is low".

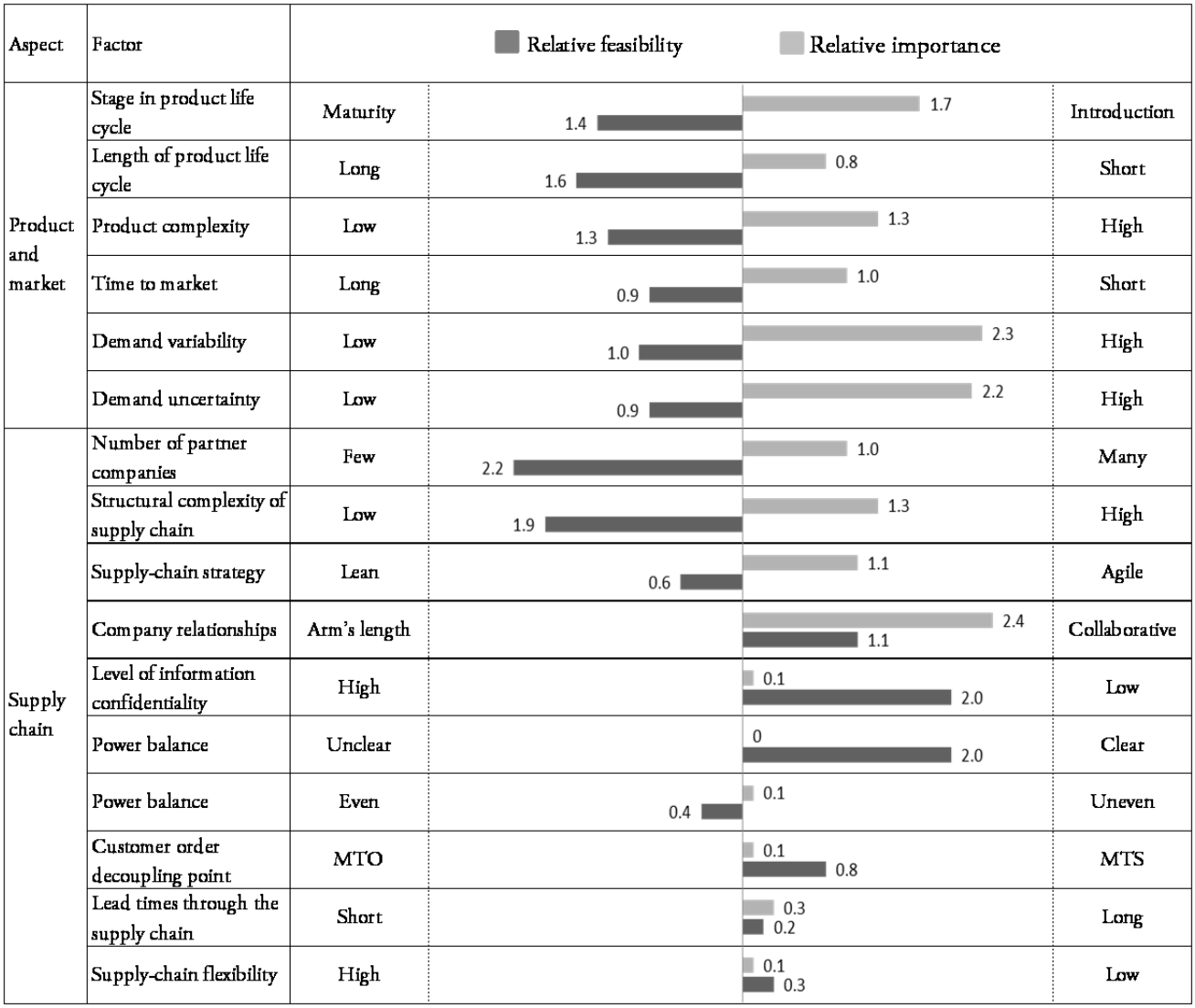

Figure 9 - Relative importance and feasibility of contextual factors.
(0 = no difference; 1 = slightly more; 2 = more; 3 = much more).

The perceived negative correlation between important and feasible contexts may help to explain why multi-tier information sharing is scarce in practice. To move forward, building on the findings reported in paper iv, one option for managers is to identify and prioritize the important contexts and thereafter investigate all possibilities to increase feasibility. Figure 10 illustrates this

approach in an importance-feasibility matrix including examples of related contexts. Regarding product and market aspects, the product characteristics such as architecture (bill of material) and product life cycle may be difficult to change in the short to medium-term range. Demand variability is also more or less a given, for example related to seasonality, demand peaks, marketing campaigns, and other promotional activities over the year. Companies could invest resources in reducing demand uncertainty, for example by improving their forecasting tools. Regarding supply chain aspects, a few of the factors can be impacted in one way or another in order to increase feasibility of multi-tier information sharing. For example, the number of companies can be reduced by only including selected key partners. By focusing on strategic partners it could also be possible to reduce the structural complexity of the supply chain. Further, developing collaborative practices and mutual trust with these selected partners could potentially clarify the power balance along the supply chain and enhance the feasibility to implement information sharing.

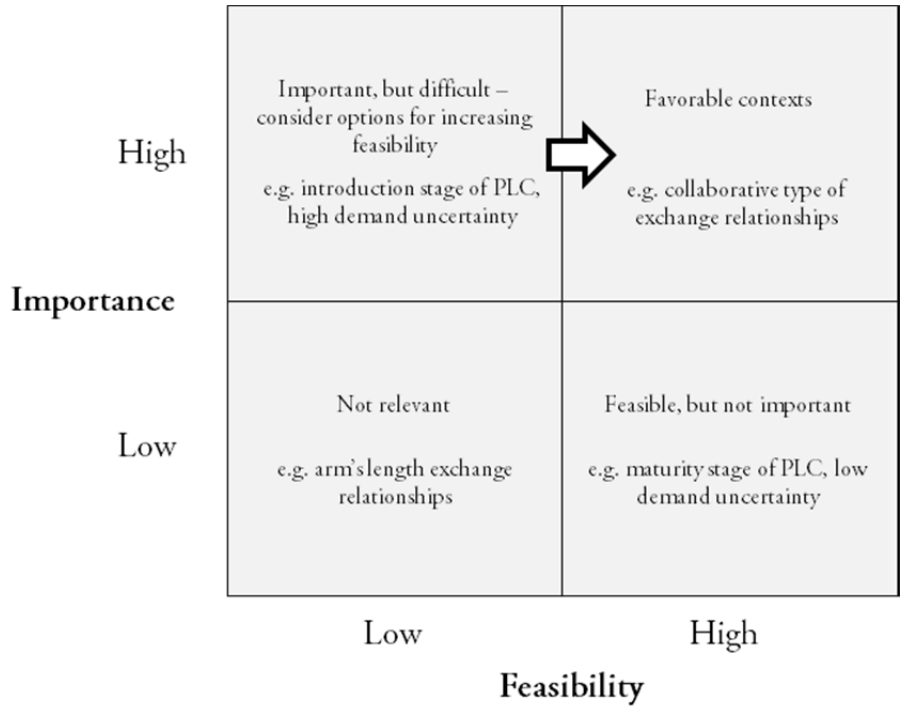

Figure 10 - Framework for importance and feasibility of multi-tier information sharing.

4.5 Paper v

Paper v is based on the same Delphi study used for paper iv. The focus of paper v was, however, different and the reported findings build on a different set of data collected in the study. The purpose of the fifth paper was to identify, structure, and categorize challenges and barriers that are associated with multi-tier information sharing. Based on input from the respondents, a barrier is defined as a challenge which likely is too difficult to overcome or solve in order to implement information sharing across three or more tiers.

We identified a total of 23 challenges to multi-tier information sharing. These challenges were, in a following step, structured and categorized through a systematic analysis conducted by a team of three researchers. The analysis, which consisted of successive clustering of challenges into groups with related content, resulted in a structure including seven categories. One category, i) supply chain maturity, appeared to be of central importance and in different ways relate to the other groups of challenges. Supply chain maturity represents a company's (lack of) ability to move beyond their internal issues and firm borders to engage and share information with their supply chain partners. The other six categories include: ii) power structure, iii) culture, iv) business process, v) legal, vi) information and vii) technology.

Power structure relates to a company's power position and ability to influence its business partners in order to initiate change in the supply chain. Culture signifies the business relationships and the attitude and willingness towards collaborating and sharing information with partners. Business process underlines the importance of having processes in place for sharing and using information in decision making as well as measuring and sharing related risks and benefits. Legal concerns what information a company is allowed to share and with whom it can be shared. The next category regards the information itself. It concerns the quality of the shared information and its value for decision making among supply chain partners. Finally, technology refers to the specific means for sharing information. It also concerns how supply chain partners can receive and make sense of the transmitted information.

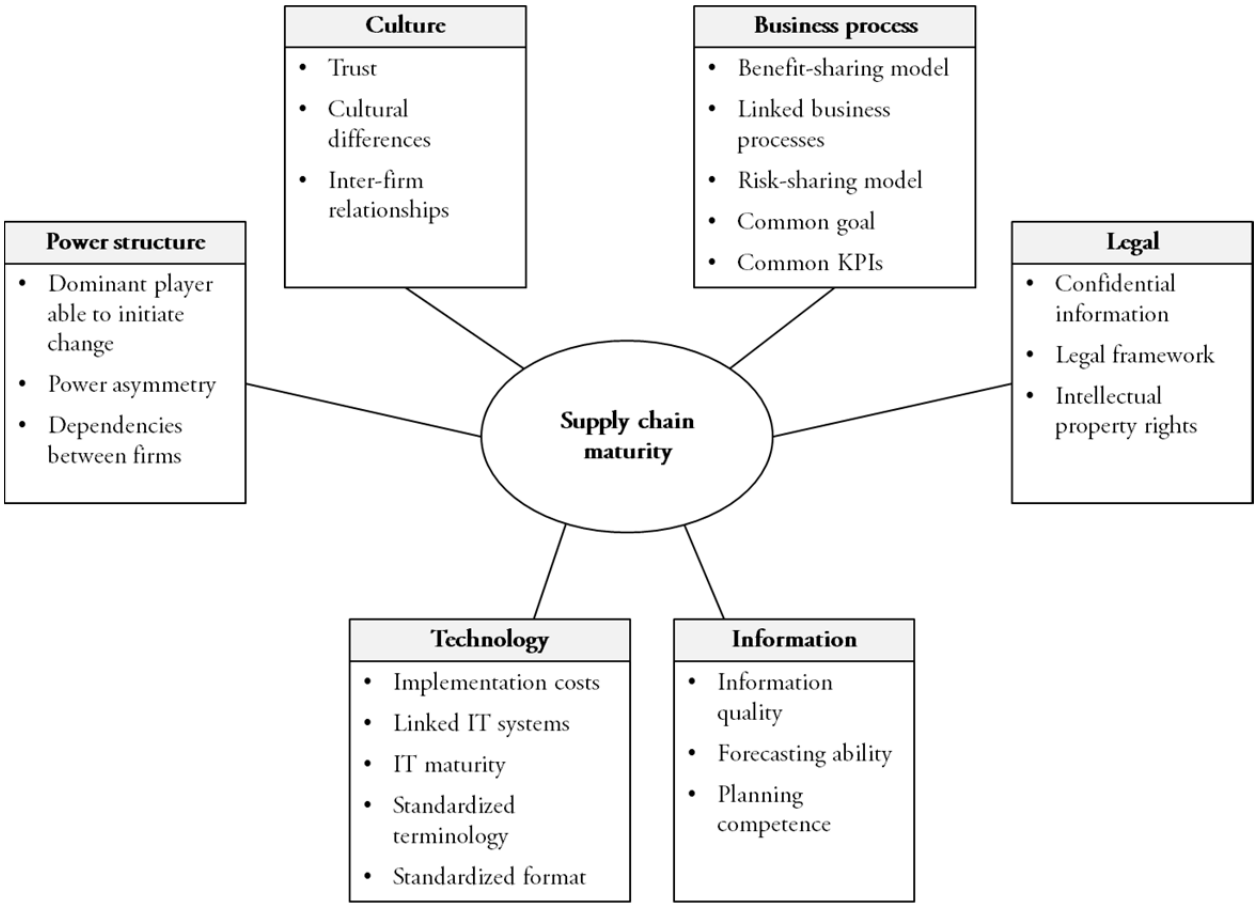

Figure 11 - Overview and categorization of challenges and barriers.

Having structured and categorized the challenges, we thereafter considered the calculated means for each of the challenges. In Table 16, from left to right, the 23 challenges and respective means are listed for (i) the entire panel, (ii) the researchers and consultants, and (iii) the SCM executives. The means are calculated using a seven-point Likert scale (where 1 is associated with a barrier, 2 = a major challenge, 4 = medium challenge, 6 = minor challenge, and 7 represents an aspect that is not even considered a challenge). The number of respondents who considered the challenges to be barriers is also highlighted in the rightmost columns.

Table 16 - Challenges and barriers to multi-tier information sharing.

Challenge	Total (N=29) Mean*	Researchers and Consultants (N= 17) Mean	SCM Executives (N=12) Mean	# Indicated as barrier Total	R&C	Exec
Supply chain maturity						
Supply chain maturity; lack of	3,2	3,5	2,9	2	1	1
Power structure						
Dominant player able to initiate change; lack of	2,8	2,4	3,4	8	7	1
Power asymmetry	3,0	3,1	3,0	9	6	3
Dependencies between firms; unbalanced	3,5	3,4	3,8	5	4	1
Culture						
Trust; lack of	2,5	2,2	2,9	13	10	3
Cultural differences	3,7	3,7	3,7	4	3	1
Good inter-firm relationships; establish	3,9	3,8	4,1	3	3	0
Business process						
Benefit-sharing model; implementation of	2,7	2,4	3,2	9	5	4
Linked business processes; lack of	3,0	3,2	2,8	5	3	2
Risk-sharing model; implementation of	3,0	2,6	3,4	4	3	1
Common goal; lack of	3,5	3,5	3,5	3	2	1
Common performance measures (KPIs); lack of	4,2	4,3	4,1	1	0	1
Legal						
Confidential information	2,9	2,9	2,9	10	6	4
Legal framework; lack of	3,3	2,9	3,9	6	6	0
Intellectual property rights; handling of	3,6	3,6	3,5	8	5	3
Information						
Information quality; lack of	2,7	2,5	2,9	9	6	3
Forecasting ability; lack of	3,8	4,1	3,3	2	1	1
Planning competence; lack of	3,8	3,7	4,0	3	2	1
Technology						
Implementation costs	3,3	3,1	3,8	8	6	2
Linked IT-systems / common platform; lack of	3,4	3,5	3,3	5	3	2
IT-maturity; lack of	3,4	3,3	3,5	5	4	1
Standardized terminology; lack of	3,8	3,6	4,2	3	3	0
Standardized format for data exchange; lack of	4,1	4,2	4,0	2	1	1

**: Mean is calculated using a 7-point Likert scale where "1" is associated with a barrier, "2" represents a major challenge, "4" a medium challenge, "6" a minor challenge, and "7" signifies an aspect that is not even considered a challenge.*

While examples from industry show that the challenges can be overcome for dyadic information sharing, they seem more difficult to resolve for multi-tier information sharing. That is why several respondents argue that the challenges actually represent barriers (cf. Table 16). The collected data highlights three reasons explaining why the challenges may be more difficult to resolve in a multi-tier setting. First, there is a lack of direct link between the sender and receiver of information, which in general means that the two partners neither have a formal contract in place nor engage in regular meetings and discussions to discuss business. As a result, it may be more difficult to build trust and understanding between the partners which, in turn, can increase the fear of opportunistic behavior and also make it more difficult to agree how to share risks and benefits. Second, supply chain structures involve embedded networks with multiple partners. Companies generally have several alternative suppliers and buyers and represent a small percentage of each other's portfolios. Therefore, the intensity of interdependence is reduced and the companies may be less willing to get tied up with a particular partner. Third, the network structure also implies that companies have many complex inbound and outbound links with multiple suppliers and purchased items as well as multiple customers and end products. As a consequence, there may be an issue with translating the information across the supply chain so that it can be used for decision making.

The findings reported in paper v imply that it is very difficult for organizations to implement the seamless flow of information across the supply chain which has been argued for in previous literature (cf. Mason-Jones and Towill, 1999; Ogden *et al.*, 2005; Kaipia and Hartiala, 2006; Melnyk *et al.*, 2009; Autry *et al.*, 2014). One of the SCM executives shared the following experience: *"With some insight into both worlds I conclude that it is much simpler to talk about multi-tier information sharing on a theoretical and conceptual level than it is in reality. It sounds very simple, but in practice it is often rather tricky, for different reasons"*.

To approach multi-tier information sharing, a conceptual framework is described in paper v, see Figure 12. The essence of the framework is to first consider supply chain maturity, and only involve partners that are able to look beyond organizational silos and internal issues, and engage with multiple partners. Having addressed the aspect of supply chain maturity, the next step is to consider power structures and business culture: i.e. do the involved partners have a culture that promotes collaboration and are they are willing to share information. The willingness dimension

should, as discussed by Fawcett *et al.* (2007), neither be disregarded nor underestimated for implementing information sharing. It is also important to identify if there is a dominant player in the supply chain that is able to take the lead to initiate change and, if necessary, enforce particular initiatives. Power can be assessed by consider, for instance, the supply chain partners' other options to achieve their goals by forming coalitions, improving their status within the network or expanding their networks (cf. Emerson, 1962). Thereafter, as illustrated in Figure 12, the partners should address business processes and legal aspects, specifying for instance: i) what information is shared with whom and when; ii) how was the information created and how should it be interpreted for decision making; iii) handling of confidential information; and iv) how are risks and benefits measured and shared in the supply chain. Eventually, the information itself and means for sharing information between partners should be addressed. Most importantly, the partners must ensure that the information is of appropriate quality so that it can be used for decision making.

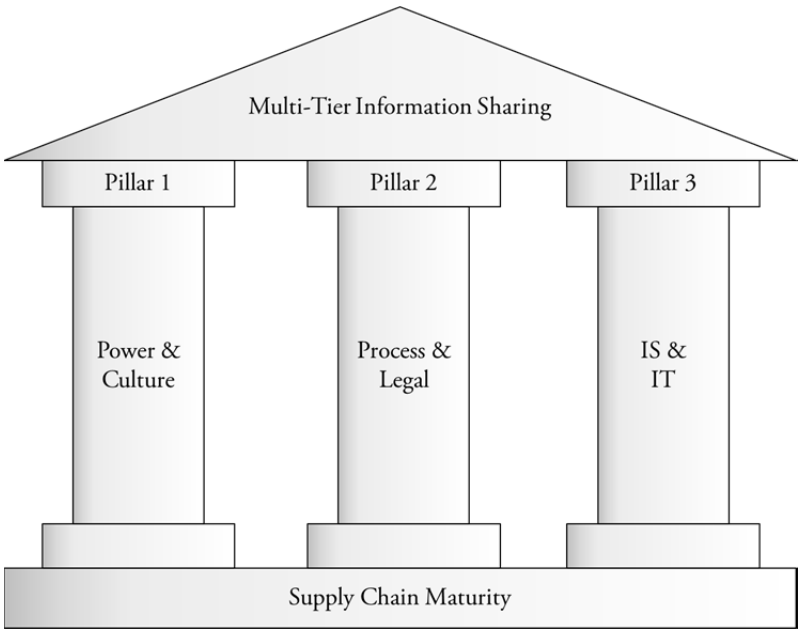

Figure 12 - Conceptual framework: challenges to implementing multi-tier information sharing.

5. Developing a framework for multi-tier information sharing

With the purpose to increase our understanding of information sharing in multi-tier supply chains, this chapter combines the findings from the three studies into one, conceptual framework. The framework aims to provide guidance to managers how to approach information sharing in supply chains in general, and multi-tier information sharing in particular. The framework builds on three steps which are described next followed by a summary and an illustration of the resulting framework.

5.1 Step 1: Identify important supply chain contexts

The first step for companies is to identify supply chain contexts where multi-tier information sharing could be beneficial. As reported in paper iv and summarized in Table 17, contexts that are perceived as important for multi-tier information sharing include product and market aspects such as the introduction stage in the product life cycle, short product life cycle, high product complexity and high demand variability and uncertainty.

Table 17 - Contexts that are perceived as important for multi-tier information sharing.

Aspect	Important context
Product and market	Introduction stage in product life cycle
	Short product life cycle
	High product complexity
	Short time to market
	High demand variability and uncertainty
Supply chain	Agile supply chain strategy
	Many partner companies
	High structural complexity of supply chain
	Collaborative type of relationships

The respondents in the Delphi study submit that multi-tier information sharing may be most beneficial in fast changing and uncertain environments where decisions have to be made without having complete information regarding future demand. This notion is elaborated by one of the panel experts: "*I believe that an important consideration for the topic of information sharing in supply*

chains is the planned changes (e.g. filling the pipeline when introducing new products, phasing out products, marketing campaigns, changes in distribution schedule or inventory levels, etc.) that different partners (primarily the ones that are closest to the end consumer, i.e. retailers or in some cases wholesalers) in the supply chain carry out, and how the information regarding these planned changes can be shared beforehand in an effective/efficient way. Based on my experience, it is precisely in these situations where information sharing is of highest importance, but at the same time the most difficult to implement and manage because sales data such as POS [point of sale] is not enough". The product and market attributes identified as important for multi-tier information sharing actually represent characteristics used to describe agile supply chains (Childerhouse and Towill, 2000). Hence, it is not surprising that the Delphi study participants also indicated multi-tier information sharing to be more important for agile in comparison with lean supply chain strategy. In an agile supply chain, attributed with volatile demand, high product variety and short product life cycle, multi-tier information sharing could help to reduce lead times in the supply chain in order to enable quick response to uncertain consumer demand.

Other supply chain contexts that are considered as important for multi-tier information sharing include the involvement of multiple collaborative partners in structurally complex supply chains. Involving additional partners may however make it more difficult to implement information sharing. As discussed in paper iii and paper v, involving multiple partners may present several challenges that may reduce the feasibility of implementing multi-tier information sharing. Such challenges include, for example, lack of information quality, lack of trust and difficulty to share risks and benefits between the partners. The number of partners to involve should therefore be carefully balanced, taking into consideration both potential benefits and reduced feasibility. With these insights in mind, the second step of the framework is to identify and involve key supply chain partners.

5.2 Step 2: Involve supply chain partners

Having identified important supply chain contexts, the next step is to consider interdependence theory for identifying which partners to engage with. Based on the findings reported in paper iii, interdependence theory appears to be useful for understanding to what extent partners share information with each other in the supply chain. Particularly, strong interdependencies seem to

bring supply chain partners together and increase the willingness to engage in inter-organizational information sharing.

Interdependence can be discussed in terms of type and intensity. Previous literature has discussed three types of interdependencies (see Thompson, 1967; Dubois *et al.* 2004): serial or sequential interdependence which exists through direct links between two companies where the output of one partners forms the input for the other; reciprocal which is recognized as the strongest type of interdependence representing mutual exchange of inputs and outputs with each actor posing contingency for the other actor; pooled interdependence where companies have no direct links but are part of and contribute to the system and to a certain extent share resources. Literature has also considered the intensity of interdependence between companies, which can be assessed by considering a range of factors such as: market shares as percentage of total expenditure/sales, number of potential buyers and suppliers, switching costs, and uniqueness in offerings (Cox, 2004). Relationships representing high intensity of interdependence include, for example, firms that represent high percentage of each other's portfolios in terms of volume and value; have few alternative buyers and suppliers; high switching costs and uniqueness in their offering.

Interdependence is generally stronger in dyadic relationships in comparison with multi-tier partnerships. As highlighted in the case study, the interdependence between *The Absolut Company* and its dyadic partners is either serial or reciprocal. Many of the dyadic partnerships also represent high intensity of interdependence which helps to explain their mutual commitment and willingness to share information. Moving beyond the dyads, however, implies that there is no direct link between sender and receiver of information. Hence, it is even more important to consider intensity of the interdependence (cf. Cox, 2004, Danese *et al.*, 2004) for understanding which partners that may be willing to engage in multi-tier information sharing.

5.3 Step 3: Increase feasibility of important contexts

Having identified important contexts as well as key partners, the final step is to consider opportunities for increasing feasibility of implementing multi-tier information sharing in the supply chain (cf. Figure 10). First of all, as previously described, feasibility can be increased by focusing only on selected partners representing high intensity of interdependence. Although the overall potential benefits may be reduced by limiting the number of partners, the challenges

involved may be less difficult to resolve. By focusing on a limited number of partners, it is likely that the structural complexity of the considered supply chain is reduced and, as a result, it may be easier to develop collaborative practices and mutual trust between the involved partners. Should the implementation be successful, then the initiative could be expanded to include other additional partners, products, components and markets.

Another approach to increasing feasibility is to consider the contextual factors representing product and market aspects included in Figure 9. Many of the product and market aspects may be difficult to change, at least in the short term. For example, redesigning a product to reduce the product complexity in terms of bill of material may take several years. Similarly, demand variability is more or less a given considering marketing campaigns, promotional activities and seasonality which cause fluctuations and peaks in demand over the year. Uncertainty of future demand could however be possible to reduce by investing time and money in relevant technology and forecasting software and by emphasizing consultative forecasting with the involved supply chain partners.

A third approach to increasing feasibility of implementing multi-tier information sharing is to address the challenges presented in paper v (cf. Table 16 and Figure 11). Particularly, it is critical to involve partners that are not stuck with a mindset of organizational silos and are preoccupied with internal issues. The involved partners should promote collaborative relationships and be ready to engage and share information with multiple partners. Further, related to power structures, a dominant player may be required to take the lead to initiate change. There should also be business processes in place for generating, sharing and using information for decision making as well as measuring and sharing risks and benefits. Related, the partners should agree on a legal framework for regulating the information flows and handling of confidential information. Finally, it is important to consider the information quality and how the information translates between the supply chain tiers so that it can be used for decision making by upstream partners. Having addressed these challenges, then the partners should also consider exactly how the information is shared between the partners.

5.4 The multi-tier information sharing framework

The resulting multi-tier information sharing framework is outlined in Figure 13. Building on the contingency approach, the framework acknowledges that information sharing has to be tailored to the particular context to potentially increase the performance for the involved partners. Hence, the first step is to identify important supply chain contexts for multi-tier information sharing. In the second step, considering the intensity of interdependence, the focus should be on involving key supply chain partners that are willing to engage in multi-tier information sharing. These first two steps of the framework are, as indicated in Figure 13, combined into a two-by-two matrix which can be used to map suppliers and customers as well as supply chains contexts with the purpose to identify favorable settings for multi-tier information sharing.

Having identified an important context and partners that are willing to participate, the third step is to increase the feasibility of implementing multi-tier information sharing. As previously discussed, it is critical to involve partners that have reached a certain level of supply chain maturity and that are able to move beyond internal issues and an organizational silo mentality in order to engage with multiple partners. Literature provides a number of useful models for assessing partners' level of supply chain maturity (see e.g. Hovmöller Mortensen *et al.*, 2008; McCormack *et al.*, 2008; Garcia Reyes and Giachetti, 2010). For instance, McCormack *et al.* (2008), describes a model with the following five steps describing how well a company has structured processes and practices: i) ad-hoc; ii) defined; iii) linked; iv) integrated; v) extended. To enable multi-tier information sharing, the involved companies should have reached the integrated or extended level. Thereafter, as highlighted in the framework, feasibility can be increased by considering the three pillars of challenges related to i) power structures & culture; ii) business process and legal aspects; and iii) the information itself and technological means for sharing the information between the supply chain partners.

Figure 13 - The multi-tier information sharing framework.

6. Conclusions, contributions and future research

The purpose of this dissertation was to investigate information sharing in multi-tier supply chains, as well as to explore opportunities and challenges to sharing information beyond the dyadic relationships. To address this purpose, a pilot study was conducted followed by three research studies: first, a systematic literature review; second, an in-depth case study; third, an extensive Delphi study. Next, the findings from the five resulting papers will be discussed together by revisiting and answering the research questions, see Table 18. Thereafter, theoretical, managerial and methodological contributions are discussed, followed by a discussion of limitations and opportunities for future research.

6.1 Revisit research questions

The first question, investigating empirical evidence of multi-tier information sharing, was addressed in each of the three studies. The second question, looking into the utility of different theories, was primarily addressed through the literature review resulting in a conceptual framework. The third question, concerning challenges and barriers to multi-tier information sharing, is answered through the case study and Delphi study. Finally, the fourth question focusing on the interaction between importance and feasibility of multi-tier information sharing is addressed through the Delphi study.

Table 18 - Revisiting the research questions.

		Literature review		Case study	Delphi study	
RQ	Description	P1	P2	P3	P4	P5
i	To what extent does empirical evidence exist of multi-tier information sharing and related benefits?	*X*		*X*	*X*	
ii	How can different theories be used and combined to analyze and better understand information sharing in multi-tier supply chains?		*X*	*X*		*X*
iii	What are the challenges and barriers to multi-tier information sharing?			*X*		*X*
iv	How do importance and feasibility of multi-tier information sharing inter-relate?				*X*	

RQ1: To what extent does empirical evidence exist of multi-tier information sharing and related benefits?

My search for empirical evidence of multi-tier information sharing and related benefits started in 2010 and has continued throughout the PhD process. During this time, I have conducted a pilot study, a systematic literature review, an in-depth case study and an extensive Delphi study, and, in conclusion, none of these studies revealed any empirical evidence of multi-tier information sharing.

To begin with, the pilot study included companies representing ten supply chains. The supply chains were purposefully selected to represent a wide variety of industries such as automotive, grocery, mining, packaging, consumer goods, and construction. To my surprise, none of the interviewees could give a concrete example of multi-tier information sharing from industry. In the following step, neither did the systematic literature review reveal any empirical evidence of multi-tier information sharing. Instead, the review highlighted a lack of research studies that extends the unit of analysis and unit of data collection beyond the dyadic relationship. The majority of the research is based on surveys of a dyadic relationship collecting data from only one company. Only a handful of research studies, all of them case studies, have investigated the extended supply chain and also collected data from all companies in the studied supply chain. The case study findings all point in a similar direction, which is that companies, for different reasons, do not engage in multi-tier information sharing (see e.g. Kaipia & Hartiala, 2006; Taylor & Fearne, 2006; Caridi *et al.*, 2014).

The case study included nine companies: the focal company, *The Absolut Company*, two market companies as well as six of their suppliers. Each of these companies is embedded in several different networks and can thus be considered to represent multiple supply chains. Therefore, also recognizing that some of the companies have worked for 30 years to develop inter-organizational information sharing, it was once again surprising to find that none of the interviewees could give a concrete example of multi-tier information sharing. In the final step, we conducted a Delphi study with multiple international experts. The panel included twelve SCM executives representing industries including, for example, information technology, telecom, automotive and fast moving consumer goods. The panel also included five researchers and twelve consultants.

Together, these experts represent multiple years of experience from working with information sharing initiatives and supply chain management in projects around the world. Again, similar to findings in previous studies, none of the experts could give a concrete example of multi-tier information sharing. As an example, one SCM executives states : *"If I look back at the years I have been working with planning supply chains I can't really say that I ever experienced real information sharing across three tiers."*

Throughout the research process, I have received a number of leads to potential cases of multi-tier information sharing. I have followed up on and investigated every lead and, eventually, realized that none of the leads actually represented a case of multi-tier information sharing as it is defined in this dissertation. The cases were either found to represent internal or dyadic information sharing, or in a few cases, the companies had initiated but, for different reasons, closed down projects related to multi-tier information sharing. Reasons for discontinuing these projects were, for example, low interest from the concerned supply chain partners due to low benefit/cost ratio. In one case, the three involved partners struggled with formalizing the information sharing arrangement, particularly regarding risk sharing related to incorrect forecasts shared between the supply chain partners. In another case, the project was discontinued because the targeted markets and products had been reduced and represented only a small share of the focal company's portfolio. The isolated pieces of information received were thus not useful for decision making in production among upstream supply chain partners. Overall, based on the examples that I have come across, the main reason for not starting up or discontinuing the projects was that multi-tier information sharing is perceived as difficult and requires a lot of resources to implement and maintain, but at the same time generates little benefits for the involved partners. One of the researchers underlines this notion: "*We have conducted trials for sharing over multiple tiers. The beneficial use cases are very limited; a lot of work and little benefit."*

To conclude, I have spent my entire PhD process searching for empirical evidence of multi-tier information sharing and I have still not been able to identify that one case. There have been many leads, but in the best case I have come across a discontinued project. Just because I did not find any cases, it does not mean that the phenomenon does not exist in industry. However, based on the findings from this dissertation, it appears that multi-tier information sharing is extremely rare in industry. This notion is supported to a large extent in all research studies conducted as part of

this dissertation. One respondent in the Delphi study elaborates: *"Information sharing is much more of an academic product than it is a phenomenon existing to a greater extent in industry … For every successful example there are at least 50 companies that don't share information in any way. And even among the successful examples, one should remember that it has taken an incredibly long time to get to the point where they are at and that the information sharing only covers a very limited part of their business."* Reasons why multi-tier information sharing may be difficult to implement are further discussed in relation to RQ3.

RQ2: How can different theories be used and combined to analyze and better understand information sharing in multi-tier supply chains?

From the perspective of critical realism, it is important to acknowledge that all empirical observations and knowledge generated throughout this dissertation are shaped by my (as well as article co-authors') prior knowledge and framing of the external reality. Considering that the access to the external reality is mediated by the theoretical and perceptual lenses that we carry, it thus becomes vital to apply different theories to analyze the collected data in order to understand and describe the investigated phenomenon (Hanson, 1958; Archer *et al.*, 1998; Saunders *et al.*, 2007; Mingers *et al.,* 2013; Volkoff and Strong, 2013). It is thus important to consider different theoretical perspectives for investigating and understanding a complex phenomenon such as information sharing in multi-tier supply chains. Power and Singh (2007 p. 1,306) support this notion, arguing that: *"mono-theoretic approach may be more conducive to studies focusing on dyadic perspectives. As a result, when trying to develop, test or verify theory outside of this narrower context, a multiple theory approach is perhaps more useful to explain the complex interplay of factors more likely to be found in the real world."*

Previous research has, as discussed in paper ii, applied a wide range of theories for analyzing and understanding information sharing between companies. The predominant theories include transaction cost economics (Kim *et al.*, 2006; Yigitbasioglu, 2010), relational governance theories (Patnayakuni *et al.*, 2006; Nyaga *et al.*, 2010), resource based view (Patnayakuni *et al.*, 2006; Tan *et al.*, 2010) and contingency theory (Grover and Saeed, 2007; Wong *et al.*, 2012). These theories are useful on their own as well as in different combinations, helping to provide different explanations for the rationale behind inter-organizational information sharing. For instance,

combining different theories highlight the importance of understanding i) the supply chain context; ii) transaction costs; iii) the risk of opportunistic behavior; and iv) relationship characteristics in order to determine what information to share with which supply chain partner.

This dissertation highlights two theories that are particularly useful for analyzing and understanding information sharing between companies in multi-tier supply chains. First, interdependence theory (Thompson, 1967) is applied in the case study with the purpose to understand how information sharing is adapted to dependence structures. As shown in paper iii, interdependence theory proves to be useful for explaining how companies work with their dyadic partners and also helps to explain why companies may be less willing to engage beyond the dyads. The theory also provides insights to the difficulties involved when there is no direct link between the sender and receiver of information. Considering both type of interdependence (Thompson, 1967; Dubois *et al.*, 2004) and intensity of interdependence (Cox, 2004; Danese *et al.*, 2004) can, as discussed in paper iii, help to understand what information companies share with whom in the supply chain and why. The intensity of interdependence can be determined by considering a set of factors (Cox, 2004).

The second theory which is applied in this dissertation is contingency theory. Although there is a lack of empirical studies applying the supply chain as unit of analysis and unit of data collection, contingency theory has been proposed as the corner stone for understanding how companies share information in the supply chain (Power and Singh, 2007). Previous research studies have suggested that one-size-fits-all solutions are not appropriate for information sharing in supply chains (see e.g. Kim *et al.*, 2006; Wong *et al.*, 2012). Instead, information sharing must be tailored for different supply chain contexts in order to increase performance of the companies and the supply chain as a whole (see e.g. Roh *et al.*, 2008; Sousa and Voss, 2008). The usefulness of contingency theory is shown in the analysis of data collected in the Delphi study. As reported in paper iv, the study identifies several contextual factors that need to be considered for multi-tier information sharing. Based on the factors, different supply chain contexts are suggested where information sharing across multiple tiers is perceived to be beneficial. From a contingency perspective, the findings also indicate a negative inter-relationship between important and feasible supply chain contexts for implementing multi-tier information sharing.

RQ3: What are the challenges and barriers to multi-tier information sharing?

The aim of the third question was to move beyond the commonly researched dyads and increase our understanding of the various challenges and potential barriers that need to be addressed to enable multi-tier information sharing.

This dissertation identified and structured a total of 23 challenges that represent seven categories: supply chain maturity, power structure, culture, business process, legal, information and technology. The categorization was the result of a systematic analysis conducted by a team of three researchers. As presented in Table 16, the major challenges include lack of trust and confidential information, lack of a dominant player that is able to initiate change, lack of linked processes for sharing information as well as risks and benefits, and lack of information quality. Many of these challenges have been discussed in previous literature in relation to dyadic information sharing (see e.g. Childerhouse *et al.*, 2003; Kemppainen and Vepsäläinen, 2003; Uzzi and Lancaster, 2003; Angulo *et al.*, 2004; Fawcett *et al.*, 2007; Harland *et al.*, 2007; Roh *et al.*, 2008; Vanpoucke *et al.*, 2009). However, while industry examples have shown that the challenges are possible to resolve between dyadic partners, this dissertation highlights that the challenges become much more difficult to resolve between partners representing three or more tiers.

The case study and the Delphi study conducted as part of this dissertation helped to identify several reasons explaining why the challenges are very difficult to resolve in a multi-tier setting. First, there is a lack of a direct link between the sender and receiver of information. This in general implies that the two partners neither have formal contracts in place nor engage in regular meetings to discuss business. As a result, it can be difficult to establish trust and also to agree on how risks and benefits will be shared between the involved partners. The second reason relates to the structure of supply chains. Companies are often embedded in several networks and have multiple suppliers and customers (see e.g. Choi and Hong, 2002). As a result, the intensity of interdependence may be reduced (cf. Cox, 2004) and companies may be less willing to get tied up and engage in multi-tier information sharing. Companies may also fear that confidential information is leaked to competitors. Moreover, the structural complexity of supply chain increases the risk of misinterpreted and/or incomplete information. Moving beyond the dyads

often implies that it is not possible to do one-to-one interpretation of information, and there is a risk that upstream partners will not be able to understand or use the received information for decision making in production.

To summarize, this dissertation has identified several challenges and underlying issues that make it difficult to implement multi-tier information sharing. Only by addressing these challenges will it be possible for companies to achieve the seamless information flows across supply chains which have been discussed and recommended by several authors (cf. Mason-Jones and Towill, 1999; Ogden *et al.*, 2005; Kaipia and Hartiala, 2006; Melnyk *et al.*, 2009; Autry *et al.*, 2014). Next, RQ4 will further discuss the aspect of feasibility in relation to the contingent nature of information sharing in supply chains.

RQ4: How do importance and feasibility of multi-tier information sharing inter-relate?

Literature seems to convey a homogenous message regarding dyadic information sharing and potential benefits. As an example, research submits that dyadic partners should share information, preferably in the shape of unformatted point of sale information, in case of high demand uncertainty and high product complexity (see e.g. Lee and Whang, 2000; Caridi *et al.*, 2010). Upstream partners can, by receiving such information, improve their planning and scheduling of production and thereby reduce inventory levels and improved service levels (see e.g. Grover and Saeed, 2007; Wong *et al.*, 2012). These recommendations are, as reported in paper iii, supported by the finding from the case study.

When it comes to multi-tier information, however, the literature is scarce. There is a lack of literature moving beyond the dyads and a gap concerning which contexts it is actually beneficial to engage in information sharing across (e.g. Choi and Liker, 2002; Li *et al.*, 2005; Autry *et al.*, 2014; Caridi *et al.*, 2014). In fact, existing literature submits that companies in general do not share information across multiple tiers (see e.g. Kaipia and Hartiala, 2006; Taylor and Fearne, 2006; Caridi *et al.*, 2014). The aim of the fourth research question was therefore to adopt the contingency perspective and investigate contextual factors that should be considered for implementing multi-tier information sharing.

Based on the Delphi study, we were able to identify a total of 16 contextual factors including a wide range of product, market and supply chain aspects. Examples of factors include stage of

product life cycle, product complexity and demand uncertainty as well as structural complexity of supply chain, supply chain strategy and type of relationship between firms (cf. Figure 9). As discussed in paper iv, the respondents indicated contexts which they perceive as important for multi-tier information sharing. Particularly, information sharing across multiple tiers is considered to be valuable for products signified by i) high product complexity; ii) short product life cycle; iii) introduction stage in the product life cycle when there is little or no historical data available; and iv) future demand is unpredictable. Meanwhile, contexts considered more feasible are represented by products representing: i) low product complexity; ii) long product life cycle; iii) maturity stage of the product life cycle; iv) low demand uncertainty. Hence, it seems as if the contexts where multi-tier information sharing is perceived to be important are different to those contexts that are regarded as feasible. In other words, contexts which may be important are not feasible, and contexts where it would be feasible to implement it would probably not be worth the effort. This negative inter-relation was also noticed among several of the supply chain factors including supply chain strategy and number of involved partners. In total, we observed the conflicting relationship between importance and feasibility for eight different factors. In fact, only one contextual factor, collaborative type of relationships, was perceived as both important and feasible.

In summary, from a contingency perspective there are some significant differences between dyadic information sharing and multi-tier information sharing. Particularly, in dyadic relationships, there are several contexts where information sharing is beneficial. Examples from industry, including the case study with *The Absolut Company*, also show that the challenges are possible to resolve. For multi-tier information sharing, however, the beneficial contexts appear to be limited. In other words, only under particular circumstances would it be valuable to move beyond the dyads and share information across multiple tiers. Furthermore, due to a number of complicating issues related to the multi-tier setting, it appears that the challenges are much more difficult to overcome. Considering both the limitation of important contexts and the difficulty to overcome the multitude of challenges can help to explain why multi-tier information sharing is a rare (if at all existing) phenomenon in industry.

6.2 Research contribution

This dissertation makes its main contribution to the research area of information sharing in multi-tier (also referred to as extended) supply chains. The main focus of the dissertation lies beyond the commonly researched dyads and, considering its exploratory and partly descriptive nature (cf. Stebbins, 2001; Yin, 2014), this dissertation contributes to increasing our understanding of multi-tier information sharing and related opportunities and challenges.

One important point made in this dissertation is the highlighted issue of studied versus reported unit of analysis. As discussed in paper i, the majority of research has focused on dyadic relationships (Choi and Liker, 2002; Li *et al.*, 2005; Autry *et al.*, 2014; Caridi *et al.*, 2014) whereas results often are claimed on the supply chain level. Moreover, as discussed by for example Kaufmann and Astou Saw (2014), research in the area of SCM has predominantly investigated phenomena from a monadic perspective (i.e. the focal company) rather than capturing multiple perspectives from various supply chain partners. Considering these gaps, a contribution of this dissertation concerns the extended unit of analysis and unit of data collection applied in the empirical studies reported in paper iii, iv and v. The case study applies the extended supply chain as unit of analysis and maps an entire network of actors and related material and information flows. This is one of the few research papers that actually investigates information sharing in a multi-tier supply chain and captures the perspective of companies representing three different tiers. Also the Delphi study was used to move beyond the dyads in order to further explore and shed light on information sharing across multiple supply chain tiers. The Delphi study enabled us to capture both the inside perspective by involving SCM executives and the outside perspective by involving senior researchers and consultants.

A second contribution relates to the streamlining of terminology and categorization of various aspects of information sharing. As noted in paper i, previous research has defined information sharing in many different ways (cf. Mohr and Spekman, 1994; Mentzer *et al.*, 2001; Wadhwa and Saxena, 2007). Considering also the issue with studied versus reported unit of analysis and unit of data collection, there is a need to harmonize the terminology used for reporting research findings in order to understand and compare findings from various studies. Streamlining the terminology could also, as discussed in paper i, be useful to develop better defined constructs and

indicators used in survey studies. To address these issues, an attempt to harmonize the terminology and categorize information sharing aspects is made in paper ii where a conceptual framework is introduced. The framework, which builds on a review of previous research, provides a categorization of information sharing according to a) reasons for (not) sharing, b) what information to share with which supply chain partner, c) means for sharing, d) barriers and drivers to information sharing and finally e) governance mechanisms.

The conceptual framework presented in paper ii also presents a range of theories that have been used to analyze different aspects and increase our understanding of (primarily dyadic) information sharing in supply chains. Similar to the research area of supply chain management, the number of theories used to analyze and understand inter-organizational information sharing continuously increases. Yet, there has previously been a lack of an integrative framework to make sense how different theories can be used for analyzing information sharing in supply chains (cf. Sahin and Robinson, 2002; Huang *et al.*, 2003). A third contribution of this dissertation is thus to describe how different theories can be used and combined to analyze and better understand information sharing between supply chain partners (cf. Figure 7). Particularly, this dissertation highlights the usefulness of interdependence theory. Interdependence theory has been downplayed in previous research but, as shown in paper iii, can be valuable to consider for analyzing and understanding information sharing in multi-tier supply chains. This dissertation also supports and extends the growing stream of literature arguing for a contingent approach to inter-organizational information sharing (cf. Kim *et al.*, 2006; Grover and Saeed, 2007; Flynn *et al.*, 2010; Wong *et al.*, 2011). Paper iv highlights the essence of adopting a contingent approach when moving beyond the dyads and understanding information sharing across multiple supply chain tiers. A total of 16 contextual factors are identified and categorized. Moreover, the findings suggest that there is a negative inter-relation between important and feasible contexts for implementing multi-tier information sharing.

Fourth, this dissertation contributes to the literature stream on challenges and barriers to information sharing in supply chains (cf. Seidmann and Sundararajan, 1998; Lee and Whang, 2000; Moberg *et al.*, 2002; Fawcett *et al.*, 2007). This dissertation identifies 23 challenges and potential barriers to information sharing beyond the dyads. The challenges are structured and grouped into seven categories. The findings from the case study and Delphi study also provide

insights to reasons why the challenges may be particularly difficult to overcome in a multi-tier setting. One reason is the lack of a direct link and the arising difficulties of not having regular meetings or formal contracts in place. For example, it becomes difficult to sort out arising issues, develop mutual trust, share benefits and risks fairly as well as develop common platforms and formats for sharing information. Another reason is relates to the network structures and multitude of suppliers and customers (cf. Choi and Hong, 2002), which in general weakens the intensity of interdependence between the supply chain partners. Third, related to the network structure, it is also difficult to translate demand information across supply chain tiers. Therefore, in a multi-tier setting, several issues arise regarding incomplete and misinterpreted information.

6.3 Managerial contribution

Considering the potential benefits, information sharing in the supply chain has received much attention among practitioners. Information sharing has, for example, been claimed to help reducing inventory levels and improving service levels among supply chain partners. Notably, information sharing has been labelled as a remedy for the, so called, bullwhip effect which continuous to create major headache for companies trying to plan their purchases and production lines. While industry cases including *The Absolut Company* highlight the potential benefits related to dyadic information sharing, there seems to be a lack of empirical evidence of multi-tier information sharing and related. This notion was supported by the studies conducted as part of this dissertation, including the pilot study, the systematic review of literature, the case study with *The Absolut Company* as well the Delphi study involving 29 supply chain experts. None of the interviewees or respondents involved in these studies could give a concrete example of multi-tier information sharing in industry. Instead, the empirical studies pointed to the many challenges and potential barriers making it difficult to implement multi-tier information sharing.

An interesting insight from the Delphi study was that several SCM executives believed that other companies had come much further and implemented information sharing across their supply chains. When asked if they could give a concrete example of multi-tier information sharing, one SCM executive stated: *"You must be able to find XX XXX number of companies that share information across several tiers"*. The same executive then provided a number of reasons why they were not themselves engaging in multi-tier information sharing. It appeared that SCM executives

in general are convinced of the value to share information across the supply chain, but in practice they perceive it as very difficult to implement. In line with previous discussion, multi-tier information sharing and the related merits are convincing on a conceptual level, but it is less feasible to implement and, hence, the companies perceive the benefits/cost ratio to be too low.

To help managers address and potentially implement multi-tier information sharing, a framework was developed and presented in chapter 5 (cf. Figure 13). Related to the proposed framework, a number of points regarding multi-tier information sharing are important to point out for managers. First of all, multi-tier information sharing is not universally beneficial. In other words, companies should carefully consider the supply chain context if it is appropriate for implementing information sharing beyond the dyads. The findings suggest that multi-tier information sharing is beneficial only in few, particular supply chain contexts. Such contexts relate to, for example, new product introductions where point of sale information is unavailable and future demand is uncertain. One of the Delphi experts elaborates: *"In the introduction stage of a product it is an absolute must to have full transparency upstream in the supply chain because of the many design changes and considering that the suppliers must be able produce according to the latest information."*

Second, it appears that the contexts which are perceived as beneficial are less feasible for implementing multi-tier information sharing (cf. Figure 9). Therefore, having identified the important supply chain contexts it is essential for companies to investigate every opportunity for increasing feasibility (cf. Figure 10). A suggested approach is to identify and start with a few high-priority markets and strategic partners, and together with these develop collaborative practices including joint systems, processes and advanced forecasting tools. In this step, it is critical to identify and involve partners who are able and willing to engage with multiple partners. Regarding ability to engage, it is important to involve partners who have moved beyond organizational silos and internal issues, and that are ready to collaborate with several supply chain partners. Regarding willingness, it can be useful to consider the intensity of interdependence. Intensity of interdependence can, for example, be described as switching costs, alternative buyers and suppliers and percentage of each other's portfolios in terms of volume and value. Should the initiative to implement multi-tier information sharing with these selected partners be successful, it may be possible to expand the initiative to other markets and partners.

Third, having identified the context and the partners to involve, feasibility can be further increased by considering the challenges and related issues identified in this dissertation. Particularly, it is important to promote a culture of trust between the partners, and ensure to implement appropriate processes for sharing and using information as well as measuring and sharing risks and benefits. It is also important to establish some kind of legal framework that regulates the information sharing. Finally, the partners must ensure that the information quality is adequate to use for decision making, and thereafter address exactly how the information is shared across the supply chain.

6.4 Methodological contribution

Previous studies have highlighted the lack of research studies expanding the unit of analysis and unit of data collection beyond dyadic relationships. However, despite continuous calls, the number of empirical studies that investigate multi-tier supply chains remains limited (see e.g. Choi and Liker, 2002; Moberg *et al.*, 2002; Barratt, 2004; Li *et al.*, 2005; Meixell and Gargeya, 2005; Giunipero *et al.*, 2008; Bastl *et al.*, 2012; Kaufmann and Astou Saw, 2014).

One reason for the lack of studies moving beyond the dyads is the portfolio of research methods dominating research in SCM, in general, and information sharing, in particular. As discussed in paper i (cf. Table 14), the survey method is by far the most applied research method, and it is primarily used to capture a monadic view of dyadic relationships. Kaufmann and Astou Saw (2014) recently reviewed survey-based SCM research and found that research studies applying the survey method rarely, if ever, move beyond the dyads. Out of 53 reviewed papers, only one considered a buyer-supplier-supplier triad whereas none of the papers looked at the extended supply chain. They further conclude that there is a lack of multiple-informant studies which are needed to represent the multi-faceted, complex and dynamic nature of supply chains. A main issue with using the survey method to collect data from multiple informants is that the data needs to be collected and analyzed as pairs. Li *et al.* (2012, p. 409) elaborates: *"a significant challenge for studying inter-firm collaboration is that information is difficult to collect and match as pairs"*. In other words, in a survey study collecting dyadic data (see e.g. Grover and Saeed, 2007), data from both partners must be collected to be able to consider that data for the statistical analysis. Hence, using the survey study to move beyond the dyads and collect data from multiple informants may be

involve tough challenges resulting in missing values and significantly reduced sample size. In light of these issues, several researchers argue that the case study is better suited for investigating complex phenomena such as information sharing between companies representing several supply chain tiers (see e.g. Ellram, 1996; Cassell and Symon, 2004; Yin, 2014). The case study enables extensive data collection from multiple firms (see e.g. Easton, 2010) and is suitable for capturing multiple views from informants across the supply chain. Nonetheless, despite its strengths, the case study still is under-represented in SCM research. Results reported in paper i indicate that only 22 out of the reviewed 82 studies (i.e. one in four) applied the case study method.

Another reason that can help to explain the lack of studies moving beyond the dyads relates to access. Based on my own experience from conducting the empirical studies, it can be difficult to get access to companies representing multiple tiers in a supply chain. There seems to be an issue of trust and perceived risk of losing control of confidential information. Moving several tiers upstream and downstream the supply chain, companies are part of multiple (in some cases hundreds) different supply chains and thus the relationship and interdependence between them and the focal company weakens. It seems that the weaker the interdependence, the more concern companies express of losing control of sensitive information. Also, the focal company has less power to convince second-tier partners to participate in a study. Considering these difficulties, it can be rather difficult to get access to partners representing different tiers in the extended supply chain. Furthermore, gaining access to the right informants and then convincing them to participate in the study can take considerable time and may eventually result in a "no thanks". Conducting a case study with multiple partners representing different tiers in the extended supply chain can thus be both extremely time consuming while also involving a risk that access is denied and data cannot be collected.

Considering the lack of research expanding the unit of analysis and collecting data from multiple informants, this dissertation makes a clear methodological contribution. The conducted case study focuses on the extended supply chain and collects data from companies representing three tiers including the focal company, first tier suppliers and first tier customers. This dissertation thus fills a critical gap to increase our understanding of the dynamics of extended supply chains. It shows that the case study method is appropriate for research on the topic of information sharing and SCM, particularly when moving beyond the dyads. This dissertation also sheds light

on the many difficulties involved when moving beyond the dyads and investigating a phenomenon when applying the extended supply chain as unit of analysis as well as unit of data collection.

Another methodological contribution lies in the application of the Delphi study to investigate information sharing in supply chains. As reported in paper i, 75 of the 82 reviewed research studies (corresponding to over 90%) apply either the survey method or the case study method. The remaining seven studies use an interview study (1 paper), secondary data (3 papers), grounded theory (1 paper), archival research (1 paper) and experiment (1 paper). The methodological toolbox thus seems to be quite restrained and mainly dependent on only two methods, i.e. the survey study and the case study. The overreliance on only these two methods becomes an issue considering the previously discussed shortcomings of the survey method. It may also be that the survey studies have not been designed properly due to the fact that the existing case studies have not provided sufficient details and insights. Related, the case study is often questioned due to its focus on particular contexts and the limited possibilities to generalize the findings beyond the specific case under investigation. The case study can, as previously discussed, also involve difficulties related to getting access to companies representing multiple tiers.

The Delphi method enabled the application of the extended supply chain as unit of analysis while collecting rich empirical data to get in-depth understanding of the researched phenomenon. The method also made it possible to move beyond the isolated case context and gather the opinions from multiple experts from academia, industry and management consulting. The strengths of the Delphi study and its usefulness for exploratory theory building have been highlighted by several authors (e.g. Klassen and Whybark, 1994; Linstone and Turoff, 2002; Akkermans *et al.*, 2003; MacCarthy and Atthirawong, 2003; Melnyk *et al.*, 2009; Giunipero *et al.*, 2012). The Delphi study makes it possible to disregard time, space and budget constraints and get access to experts' extensive experience from working with the topic at hand; in this study both from the inside of firms (SCM executives) and from outside actors (researchers and consultants). The Delphi study enables data collection in several rounds where the respondents share knowledge and have the opportunity to confirm their viewpoints. The respondents also are anonymous which reduces potential negative effects related to interpersonal biases, unproductive disagreements or defensive attitudes.

Considering the strengths and characteristics of the Delphi study, it is a useful addition to the methodology toolbox used in SCM research. In comparison with the survey study and the case study method, it provides both an opportunity to collect rich commentary input to get in-depth understanding of the phenomenon while also allowing the researcher to generalize the findings to a certain extent. Several research studies have combined commentary input in the first one or two rounds with a quantitative round using, for example, a seven point Likert scale to collect quantitative data. Hence, the Delphi method could be considered useful as a bridge between quantitative and qualitative research methods drawing on the strengths of mixed-method research.

6.5 Limitations and opportunities for future research

Like any other research study, this dissertation has certain limitations (cf. section 1.5 on delimitations of the study). Limitations are important to consider as they have an impact on the transferability of the findings and conclusions, i.e. the extent to which the study is able to make general claims about the world (Halldorson and Aastrup, 2003). Considering the limitations, several related opportunities for further research are suggested.

One limitation is that the systematic literature review only included papers published in ten, selected journals. It could be that relevant research findings have been published elsewhere, for example in other journals, conferences proceedings or as part of book chapters. Nonetheless, by focusing on ten, recognized journals, all reviewed papers have undergone a rigorous review process which increases the credibility of the material reported in paper i and ii. Also, building on the systematic literature review, additional reviews of literature have been done throughout the PhD process to ensure that relevant literature is considered in the frame of reference.

A second limitation is that the case study focuses on one single product (70cl Absolut Citron) with certain characteristics and two markets (Sweden and UK). Although following a rigorous sampling process (cf. Patton, 2002), the studied supply chain context presents certain limitations as to how the findings can be generalized. Particularly, the case study emphasizes functional products and does not focus on innovative products (cf. Fisher, 1997) which, based on the findings in this dissertation, appear to be more important for multi-tier information sharing. Hence, an opportunity for future research would be to consider innovative products with

characteristics of, for example: short product life cycle and frequent launches of new products. Particularly, considering input from the Delphi study, new product introductions and similar planned changes in the supply chain can be interesting to investigate in future research.

Moving beyond the isolated case, the Delphi study provides additional insights to the studied phenomenon. A potential limitation of the Delphi study is the background of the panel experts. While the group of researchers is truly global, the consultants and SCM executives primarily represent the Nordic countries. However, all experts were invited based on their expertise and, regardless of where in the world they are currently stationed, they all have extensive experience from global supply chain management. Another potential limitation is the limited number of researchers that are included in the panel. Several of the senior consultants included in the Delphi panel however have a background in academia and several years of experience from conducting research on related topics.

Another possible limitation is that the twelve SCM executives included in the panel represent a limited number of industries. We aimed to include a wide variety of industries including, for example, information technology, telecom, automotive and fast moving consumer goods. We also ensured to include every industry where we had received notice of potential cases of multi-tier information sharing. Despite these efforts, it is possible that there are other industries that could have been valuable to consider. Related to this limitation, it is important to highlight the focus of this dissertation on supply chains involving one or more manufacturers. Considering this focus, the case study investigated an extended supply chain involving three tiers of manufacturing. Also, the SCM executives involved in the study primarily represent supply chains included some kind of production.

Including production involves a bill of material which makes it more difficult to translate demand information across the supply chain. One consultant in the Delphi study elaborates: *"[i]t is impossible to do one-to-one interpretation of data, except in pure distribution cases" (Consultant).* Hence, removing production and focusing on pure distribution cases could significantly reduce the complexity and difficulties related to information quality. The following quote from one of the researchers in the Delphi study underlines this notion: *"Technically information sharing is possible across the whole supply chain, and the benefits have been proved in many studies, particularly*

in model-based studies. Information sharing benefits in practice are more challenging to be realized in a three-tier supply chain, in particular manufacturers have faced difficulties in realizing those." In light of these insights, future research could consider investigating retailing and distribution cases where it potentially could be more feasible to implement multi-tier information sharing.

Another limitation of the dissertation is the emphasis on qualitative data collection in the case study and the Delphi study. Hence, there is a lack of quantitative data collection and analysis. The Delphi study, particularly the last round of the study, provided an opportunity to use a seven point Likert scale. However, the possibility to do statistical analysis was limited considering that the panel included a total of 29 respondents. The possibility to generalize some of the findings is therefore limited.

Building on the findings from this study, there are several options for moving the research area forward. One avenue would be to consider the contextual factors and further investigate favorable supply chain contexts for multi-tier information sharing. In-depth and multiple case studies could be useful to describe and compare the particular circumstances that enable multi-tier information sharing. The factors and potential causal relationships among factors could also be tested through the application of a survey study. Particularly, it would be interesting to building on the proposed framework outlining various challenges (cf. Figure 12) to investigate sequential dependencies between the categories of challenges. In other words, is it reasonable from a theoretical point of view to assume that companies should first address challenges related to power structures and culture before resolving process- and legal related challenges, and thereafter consider the information quality and means for sharing across the supply chain?

Further investigation is also warranted to increase our understanding of the interaction between importance and feasibility to implement multi-tier information sharing. It appears that feasibility is low for contexts which are perceived as beneficial. It would therefore be valuable to investigate how feasibility could be increased. Considering that this dissertation has not looked into means for generating, sharing and using information, these could be interesting to investigate further. Such research could for example consider the implementation of new technology for forecasting demand as well as handling of big data considering the large amount of information that needs to be shared across the supply chain.

Further, considering the many challenges and barriers identified in this dissertation, future research could provide additional empirical evidence of the impact of these obstacles. Particularly, as highlighted by the Delphi experts, the role of a dominant player seems critical for implementing multi-tier information sharing. Future research could thus investigate the role of the dominant player and the possibility to overcome the challenges identified in paper v. Such research could build on previous studies on power and (inter)dependencies (see e.g. Emerson, 1962; Rowley, 1997; Danese *et al.*, 2004, Cox, 2004).

Finally, considering the recognized difficulties of implementing multi-tier information sharing, a worthwhile research project would be to consider alternative ways forward for supply chain partners. The problems with bullwhip effect, incorrect production plans, poor delivery precision and high inventory levels do and likely will continue to exist in industry. Future research could thus investigate how successful companies find other ways to deal with the problems to reduce the bullwhip effect and improve performance by, for example, reducing inventory levels in their organizations and throughout the supply chain. One possibility, as briefly discussed in paper iii, would be to investigate connected dyads, i.e. dyads of dyads to see how different dyads with strong interdependence could be connected to help improve performance.

6.6 Concluding discussion

This dissertation is original in that it moves beyond the commonly researched dyads to empirically investigate information sharing in multi-tier supply chains. There are several unique insights that are important to highlight in this concluding discussion.

One of the key insights from this dissertation relates to the differences between sharing dyadic information and sharing across multiple tiers. These differences may, initially, seem to be less of an issue. However, as highlighted in the empirical studies, adding that third tier has major implications for information sharing. Particularly, i) partners are embedded in multiple networks each involving a large number of suppliers and customers; ii) partners represent weaker type and intensity of interdependence; iii) the sender and receiver of information has no direct link including formal contracts and regular business meetings; and iv) demand data is difficult to translate across tiers due to issues concerning incomplete and misinterpreted information. Related, there are several other challenges that must be addressed, including the lack of trust, lack

of processes, lack of legal framework and lack of information quality. And, adding to that, there seems to be a negative inter-relation between important and feasible supply chain contexts for multi-tier information sharing. All considered together, moving beyond the dyads really is not just about adding one more partner and continue doing the same thing that went well in the buyer-supplier relationship. Multi-tier information sharing appears to require much more engagement and efforts from the involved partners. Hence, from a theoretical point of view, it may be a major issue when research studies investigate dyadic relationships and thereafter extend the implications and conclusions to the extended supply chain. Eventually, the theories that are being developed may be just conceptual ideas rather than grounded in and representing the real world.

The many issues involved when moving beyond the dyads may also help to explain why it has been so difficult to find cases of multi-tier information sharing. Considering that, together with the insight that companies still struggle with internal issues and operate with an organizational silo mentality, suggests that the way is probably very long before companies will shift their focus beyond their dyadic partnerships. It may actually be that the way companies do business today is not fit for moving beyond the dyadic relationships. Again and again, research studies report on the issues of trust and sharing risks and benefits. It could very well be that companies need to find new ways of doing business involving multiple partners. One of the SCM executives in the Delphi study elaborates on this notion: *"Mature supply chains have less interest in taking risks related to information sharing because the structures are created around other incentives. In the start-up of a new supply chain, risks and possibilities are shaped and the partners are more prone to think in new ways and implement new solutions. In addition, if there is mutual trust between the key partners the feasibility is greater."*

The findings in this dissertation can also be put in perspective of related research areas, including supply chain visibility, supply chain integration and supply chain management. Reviewing literature on these areas seems to convey a similar message as for information sharing. Much of the research that applied the supply chain as unit of analysis has been conceptual or, as in the case of information sharing, used analytical methods including mathematical modelling (cf. Wacker, 1998). Meanwhile, the empirical research has predominantly been limited to the dyadic unit of analysis, although implications and conclusions often seem to be discussed on the supply chain

level. As previously discussed, this approach may eventually lead to a major problem when theory does not reflect reality. As one example, supply chain visibility was originally discussed in terms of sharing of information from end to end of the supply chain, i.e. from raw material supplier to the end consumer. Reviewing the literature on supply chain visibility however reveals that few studies actually applied the end to end supply chain as unit of analysis and unit of data collection. Hence, the unit of analysis and unit of data collection have been narrowed down step by step, but implications and conclusions have at times been reported for the end to end supply chain. Unfortunately, this disconnection has caused much confusion in literature dealing with supply chains and as of today it is difficult to understand what a researcher refers to when claiming that they apply the "supply chain" as unit of analysis: it could be three or more tiers, a dyadic relationship, or just internal within a company. In light of these issues, it is critical that future research studies clearly describe the unit of analysis and the unit of data collection. Thereby it will be possible to further develop interesting theories.

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Appendix i: Interview guide, Pilot study

1) Defining information sharing
   - Please explain what the term "information sharing" means to you.
2) Suppliers
   - What information do you share with your suppliers?
   - What information do your suppliers share with you?
3) Customers
   - What information do you share with your customers?
   - What information do your customers share with you?
4) Extended Supply Chain
   - What information do you share in the extended supply chain (e.g. with supplier's supplier or customer's customer)?
5) Means for information sharing
   - How do you share information with other companies?
6) Future initiatives
   - Do you foresee or plan to share additional information within the next 5 years? If yes, what and why?
   - Would you like to receive additional information? If yes, what and why?
   - Are there any barriers to sharing additional data/information/knowledge?

Appendix ii: Interview guide, Case study

1) Physical flows: Describe the physical flows for products/components handled in relation to *The Absolut Company*.
2) Information flows: What information do you share with suppliers (and suppliers' suppliers) / customers (and customers' customers) on a strategic/tactical/operational level, and what are the related benefits?

(Related to three organizational levels and respective decision time horizon: strategic (beyond 6 months) for example forecasts, market trends, ability to grow; tactical (2 weeks – 6 months) e.g. material requirement planning, safety stock and allocation of capacity; operational (less than 2 weeks) e.g. order status, inventory levels, lead times, production schedules).

3) Do you share different types/amount of information with different suppliers/customers? If yes, please describe and explain why.
4) Do you wish to increase/extend information sharing with any of your suppliers/customers? If yes, what type of information, with whom and why?
5) Related to question 4, are there any challenges to increase/extend information sharing? Particularly, what are the challenges of sharing information beyond dyadic supply chain relationships?

Appendix iii: Questionnaires (round 1, 2, 3), Delphi study

Invitation letter

Dear _____,

Based on your experience in the field, we would like to include you as an expert in our panel on the topic of information sharing in the supply chain focusing on three or more tiers.

Since 2010 we conduct a research project at Lund University, focusing on benefits of sharing information (such as point of sales data, forecasts, marketing campaigns, capacity constraints) over three or more supply chain tiers (e.g. second tier supplier – supplier – manufacturer – retailer – customer). There are many examples, in both theory and practice, on information sharing between two companies (supplier – buyer) but very little on information sharing across multiple tiers. Therefore it is important to capture issues and insights regarding this phenomenon from experts representing senior researchers, industry representatives and consultants.

In this letter you will find four questions that we would like you to give your most honest opinion on and send us by email. As a panel member you will have two additional opportunities to complement and comment on the results and conclusions. These will take place during spring 2014 and will take approximately 15-30 minutes each. Throughout the process we guarantee complete anonymity.

As a token of appreciation for participating in this study we will send you the final report. We hope that you find this research interesting and that you are willing to take part as one of our panel experts.

We need your answers by Wednesday, February 12. If you have any questions regarding the study, please contact Joakim Kembro +46 46 222 33 27. Also, we would appreciate if you recommend others who have relevant experience in the topic of this study.

With best regards,

Round 1 questionnaire

Dear _____,

In Round 1 you will find two questions that we would like you to give your most honest opinion on. As a panel member you will, during the next six months, have additional opportunities to complement and comment on the results and conclusions. Throughout the process we guarantee complete anonymity.

Question 1: Is there any difference regarding sharing information across independent companies representing three or more supply chain tiers (e.g. supplier – manufacturer – retailer) in comparison with information sharing between dyadic partnerships (supplier – buyer)?

If yes,

- What is the difference in general terms?
- What factors should be considered for information sharing across three or more tiers, particularly in comparison with dyadic sharing? Suggest and motivate a maximum of five factors (internal or external).
- What are the specific challenges and/or barriers to information sharing across three or more tiers, particularly in comparison with dyadic sharing? Suggest and describe a maximum of five factors (internal or external).

If no, why is there no difference? Please motivate your answer.

Question 2: Why do you think companies should / should not share information (such as point of sales data, forecasts, promotional activities and capacity constraints) across three or more supply chain tiers? What information should be shared and what information should not be shared?

Question 3: Is there any particular supply chain context/setting (e.g. type of industry or product) where it is more likely that companies could benefit from information sharing across three or more tiers?

Question 4: Is there anything else that you find relevant considering information sharing in the supply chain?

We also wonder if you are aware of any case where companies do share information across three or more supply chain tiers. If yes, we would be grateful if you could provide a short description and, if possible, share contact information.

Round 2 questionnaire

Dear _____,

Round 2 is based on a synthesis of comments and ideas that emerged from round 1. You also have the opportunity to provide comments.

Question 1: Is there any difference between information sharing across three or more supply chain tiers (e.g. supplier – manufacturer – buyer) in comparison with sharing between only two partners (dyadic relationship)?

a) "No difference": The same level of complexity applies to sharing information across three or more supply chain tiers as between dyadic partners.

b) "Amplification": Information sharing across three or more supply chain tiers involves increased complexity, but the challenges and problems are fundamentally the same as experienced in dyadic information sharing:

- Increased number of actors.
- Increased number of activities, processes and decisions.
- More difficult and time consuming to interpret and use information.
- More challenging to standardize data and link IT systems together.

c) "New dimensions": There are new dimensions that must be considered for information sharing across three or more tiers, for example:

- For producing companies, in each node, completely different components and products flow in and out; these are disconnected with respect to the product structure (bill of material).
- A supply chain is rather a network where purchased quantities for an item can be divided between different suppliers and a product can be sold to several customers.

Question 2: Which of the following factors can be considered a barrier or a challenge to implementing information sharing across three or more supply chain tiers (e.g. supplier – manufacturer – buyer)?

- Barrier is a factor which likely is too difficult to overcome or solve in order to implement information sharing across three or more tiers.
- Challenge is a complicating factor which likely can be overcome or solved in order to implement information sharing across three or more tiers.

For each factor, indicate whether you think it can be considered as i) a barrier, ii) a challenges, iii) neither barrier nor challenge; or iv) indicate that you don't know.

1. Benefit-sharing model (implementation of)
2. Risk-sharing model (implementation of)
3. Confidential information (handling of)
4. Legal framework: control of information sharing (lack of)
5. IT-maturity (lack of)
6. Linked IT-systems / common platform (lack of)

7. Standardized format for data exchange (lack of)
8. Standardized terminology to interpret information (lack of)
9. Good inter-firm relationships (establish)
10. Power asymmetry
11. Dependencies between firms (unbalanced)
12. Trust (lack of)
13. Planning competence (lack of)
14. Forecasting ability (lack of)
15. Distance between companies
16. Capacity flexibility
17. Capacity limitation
18. Standardized business processes (lack of)
19. Linked business processes (lack of)
20. Supply chain maturity (collaboration practices)
21. Intellectual property rights (handling of)
22. Cultural differences (handling of)
23. Ability of dominant player to initiate change (lack of)
24. Information quality (lack of)
25. Implementation costs

Question 3: Which of the following factors are important to consider when designing information sharing across three or more supply chain tiers (e.g. supplier – manufacturer – buyer)?

1. Stage in product life cycle
2. Product life span
3. Number of involved companies
4. Lead times through the supply chain
5. Customer order decoupling point
6. Supply-chain strategy (e.g. lean, agile)
7. Production capacity
8. Flexibility in production capacity
9. Start-up times in production
10. Demand uncertainty
11. Time to market
12. Product complexity (bill-of-material)
13. Power balance
14. Company relationships
15. Product margins
16. Structural complexity of the supply chain
17. Level of information confidentiality

Round 3 questionnaire

Dear _____,

This round is based on a synthesis of comments, suggestions and ideas that emerged from rounds 1 and 2. You also have the opportunity to provide comments.

Question 1: Which of the following factors can be considered a barrier or a challenge to implementing information sharing across three or more supply chain tiers (e.g. supplier – manufacturer – buyer)? Please indicate a number between 1 and 7 according to the following 7-point Likert scale: 1 = barrier; 2 = major challenge; 4 = medium challenge; 6 = minor challenge; 7 = not even a challenge.

1. Benefit-sharing model (implementation of)
2. Risk-sharing model (implementation of)
3. Confidential information (handling of)
4. Legal framework: control of information sharing (lack of)
5. IT-maturity (lack of)
6. Linked IT-systems / common platform (lack of)
7. Standardized format for data exchange (lack of)
8. Standardized terminology to interpret information (lack of)
9. Good inter-firm relationships (establish)
10. Power asymmetry
11. Dependencies between firms (unbalanced)
12. Trust (lack of)
13. Planning competence (lack of)
14. Forecasting ability (lack of)
15. Linked business processes (lack of)
16. Supply chain maturity (collaboration practices)
17. Intellectual property rights (handling of)
18. Cultural differences (handling of)
19. Ability of dominant player to initiate change (lack of)
20. Information quality (lack of)
21. Implementation costs
22. Common goal (lack of)
23. Common set of performance measures (KPIs) (lack of)

[For reference] the list is same as in Round 2 – Question 2 with the following changes:

Four factors were removed: Distance between companies; Capacity flexibility; Capacity limitation; Standardized business processes

Two factors were added: Common goal (lack of); Common set of performance measures (KPIs) (lack of)

Question 2: Please indicate relative importance and relative feasibility for each of the following contextual factors. Below, we have included one example to clarify and provide guidance.

List of contextual factors

1. Stage in product life cycle	Introduction	vs	Maturity
2. Product life span	Short	vs	Long
3. Number of involved companies	Few	vs	Many
4. Lead times through the supply chain	Short	vs	Long
5. Customer order decoupling point	MTS	vs	MTO
6. Supply-chain strategy	Lean	vs	Agile
7. Supply-chain flexibility	Low	vs	High
8. Demand variability	Low	vs	High
9. Demand uncertainty	Low	vs	High
10. Time to market	Short	vs	Long
11. Product complexity	Low	vs	High
12. Structural complexity of supply chain	Low	vs	High
13. Power balance	Clear	vs	Unclear
14. Power balance	Even	vs	Uneven
15. Company relationships	Arm's length	vs	Collaborative
16. Level of information confidentiality	Low	vs	High

Example question (factor #4 in above list)

Leadtimes through the supply chain

	Long			vs.		Short	
Indicate in which setting you believe that Information sharing beyond dyads is relatively more	Much more	More	Slightly more	**Equal**	Slightly more	More	Much more
a) Important	☐	☒	☐	☐	☐	☐	☐
b) Feasible	☐	☐	☐	☐	☒	☐	☐

- Please note that we, in the above example, contrast between long and short lead times through the supply chain. (for each of the contextual factors, different ranges/contexts are being contrasted)
- With the above answers, the respondent indicates that:

a) information sharing beyond dyads is more important in a supply chain with long lead times.

b) Information sharing beyond dyads is slightly more feasible in a supply chain with short lead times.

Appendix iv: Appended papers

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

ii. Kembro, J., Selviaridis, K., and Näslund, D. (2014). "Theoretical perspectives on information sharing in supply chains: a systematic literature review and conceptual framework." *Supply Chain Management: An International Journal* 19(5/6):609-625.

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Information sharing in supply chains, myth or reality?

A critical analysis of empirical literature

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Abstract

Purpose

The purpose of this paper is to investigate what empirical evidence exists regarding benefits of information sharing in supply chains, and to identify potential gaps and opportunities in this research area.

Design/methodology/approach

The authors conducted an in-depth, systematic literature review and multilevel analysis of 82 selected articles. In the analysis, the authors investigated: if the articles applied the supply chain as the unit of analysis; the selected research method; if the articles applied the supply chain as the unit of data collection (i.e. collected data from three or more different companies); and finally, aspects of information sharing – including benefits.

Findings

Despite anecdotal descriptions of benefits from information sharing in supply chains, the authors could not find empirical evidence to support these claims. Rather, the main body of literature reports on a focal company's perspective on traditional buyer-supplier relationships.

Research implications

Given the lack of evidence for the claimed benefits of information sharing on a supply chain level, more research is needed in this field. The authors therefore propose an agenda for future research building on four key points.

Originality/value

Contrary to popular belief, empirical evidence for benefits of information sharing in supply chains does not seem to exist. This article highlights an issue previously not addressed with a systematic in-depth review and analysis of empirical articles.

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Keywords: Supply Chain Management, Information Sharing, Systematic Literature Review

Introduction

The topic of information sharing in supply chains has interested researchers for decades (e.g. Forrester, 1958; Sternman, 1989; Cooper, Lambert, and Pagh, 1997; Lee and Whang, 2000; Yu *et al.*, 2010). The research field appears to be divided into two groups. One group of academics propose that shared information could lead to tangible benefits such as improved forecasts and reduced inventory levels (Seidmann and Sundararajan, 1998; Lee, So, Tang, 2000); create value via enhanced planning and decision making processes (Sahin and Robinson, 2002; Mohr and Spekman, 1994) and lead to improved long-term relationships (Premus and Sanders 2008). To realize these benefits data, information and knowledge should be shared at different organizational levels between members in the supply chain (Wadhwa and Saxena, 2007). For instance, it is recommended to share daily information about logistics activities such as order status, inventory levels (Moberg *et al.*, 2002; Premus and Sanders, 2008) and delivery schedules (Li *et al.*, 2006) on the operational level; short-term forecasts (Bowersox *et al.*, 2000), production planning (Yigitbasioglu, 2010) and capacity information (Yu *et al.*, 2010) on the tactical level; and long-term logistics strategies, understanding of market trends (Li *et al.*, 2006) and ability to grow (Mohr and Spekman, 1994) on the strategic level.

However, another cluster of researchers seems more skeptical, indicating that information sharing in supply chains in reality is limited due to complexity, costs and risks (see e.g. Kemppainen and Vepsäläinen 2003; Uzzi and Lancaster 2003; Samaddar *et al.* 2006; Roh *et al.*, 2008; Vanpoucke *et al.* 2009). The task of determining what information should be shared and with whom is a complex task, especially since supply chains tend to evolve over time and information sharing may require involvement of several different partners (Samaddar *et al.* 2006). Costs range from resources committed in design and implementation stages to applications (Uzzi and Lancaster, 2003; Roh *et al.*, 2008). Adding to the cost issue, Vanpoucke *et al.* (2009) state that companies are often disappointed by the low cost/benefit ratio of information sharing applications. Risks include potentially reduced power and/or competitiveness (Uzzi and Lancaster, 2003; Seidmann and Sundararajan 1998). Finally, there is also a concern of how to allocate the claimed benefits of increased information sharing in supply chains (Lee and Whang, 2000).

There are, in other words, two disparate views of the current status of information sharing in supply chains. Furthermore, there appears to exist terminology confusion in academic literature regarding what authors actually refer to when they discuss information sharing in supply chains, including boundaries of the studied supply chain. Thus, there is a need to analyze existing empirical research in a structured manner in order to describe the actual status of information sharing in supply chains. Only by conducting a review in terms of which part of the supply chain was investigated; where in the supply chain data was collected; how data was collected; and what aspects of information sharing were investigated (why, what, how, barriers and driving forces) can we evaluate the potential empirical evidence for the claimed benefits of information sharing in supply chains.

The overall purpose of this paper is to evaluate whether or not there is empirical evidence for benefits of information sharing in supply chains. In the following section we define what we mean by a supply chain and by information sharing in supply chains. We then present the methodology and the classification framework for analysis of the reviewed articles. Thereafter, we present the results of the literature

review followed by a discussion of the implications. We conclude by proposing an agenda for future research on information sharing in supply chains.

Defining information sharing in supply chains

For the definition of a supply chain, we adopt the definition by Mentzer *et al.,* (2001, p. 4): *"a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer."* In other words, a single company or a dyad is not considered to constitute a supply chain; they are parts of a supply chain. Regarding *information sharing*, the term has been defined in many different, and sometimes conflicting, ways, see Table 1. For instance, referring to the Global Logistics Research Team, Mentzer *et al.* (2001, p. 8) define information sharing as "*the willingness to share strategic and tactical data with other members of the supply chain,"* whereas Mohr and Spekman (1994, p. 139) define it as *"the extent to which critical, often proprietary, information is communicated to one's partner."* Wadhwa and Saxena (2007) argue that information sharing relates not only the sharing of information, but also sharing of data and knowledge. Therefore, to streamline the terminology and avoid confusion, we define information sharing in supply chains as the *"inter-organizational sharing of data, information and/or knowledge in supply chains."*

Table 1 - Overview of definitions for the term "information sharing"

Author/Year	Definition
Cao *et al.* (2010)	The extent to which a firm shares a variety of relevant, accurate, complete and confidential ideas, plans, and procedures with its supply chain partners in a timely manner
Hsu *et al.* (2008)	The extent to which crucial and/or proprietary information on the tactical and strategic level is available to members of the supply chain
Mentzer *et al.* (2001)	The willingness to make strategic and tactical data available to other members of the supply chain
Mohr and Spekman (1994)	The extent to which critical, often proprietary, information is communicated to one's partner
Moinzadeh (2002)	The availability of online information of retailers' inventory positions to the supplier
Olorunniwo and Li (2010)	The extent to which data is accessible to partner firms through mutually agreed exchange infrastructure
Rai *et al.* (2006)	The extent to which operational, tactical and strategic information are shared between a focal firm and its supply chain partners
Wadhwa and Saxena (2007)	Sharing of end customer demand and lead time to adjacent or all supply chain nodes
Wiengarten *et al.* (2010)	The act of capturing and disseminating timely and relevant information for decision makers to plan and control supply chain operations

Methodology

As recommended by Tranfield *et al.* (2003), we conducted a systematic review to produce a reliable knowledge stock. The systematic review entails a transparent and replicable process that reduces bias and error by exhaustive literature searches as well as details on the reviewers' decisions, procedures and conclusions. Based on the National Health Service Dissemination, Tranfield *et al.* (2003) present a list of three stages in conducting systematic review: 1) planning the review; 2) conducting the review; and 3) reporting and dissemination.

In the planning stage, we set up a review protocol describing the identified need for literature review as explicated in the introduction. Tranfield *et al.* (2003, p. 215) confirm that a *"management review protocol may contain a conceptual discussion of the research problem and a statement of the problem's significance rather than a defined research question."* The protocol also detailed the search strategy and criteria for inclusion and exclusion. To identify contemporary research on information sharing in supply chains, we focused on the years 2000 – 2012 and searched for peer-reviewed articles in two recognized databases: *Thomson Reuters (formerly ISI) Web of Knowledge* and *SciVerse Scopus*. To ensure a good knowledge foundation we included 10 journals in the review. Journal selection was based on three criteria: 1) journals that include empirical research articles and are well represented in the fields of supply chain management (SCM), operations management (OM), management information systems (MIS) and operations research (OR); 2) journals that we have found to be well represented in previous literature reviews related to information sharing in supply chains; 3) the ranking of journals in related fields as listed in the Harzing Journal Quality List (http://www.harzing.com/jql.htm). The selected journals are presented in Table 2.

Table 2 - Journals included in the literature review

Journal	Field
Supply Chain Management, An International Journal (SCMIJ)	SCM
Journal of Supply Chain Management (JSCM)	SCM
International Journal of Physical Distribution and Logistics Management (IJPDLM)	SCM
Journal of Operations Management (JOM)	OM
Journal of Business Logistics (JBL)	OM
International Journal of Operations and Production Management (IJOPM)	OM
Decision Science (DS)	OR
International Journal of Production Economics (IJPE)	OR
Management Information Systems Quarterly (MIS Quarterly)	MIS
Journal of Management Information Systems (JMIS)	MIS

The second stage of the systematic review began with identifying keywords and search terms, which along the lines of Tranfield *et al.* (2003, p. 215) were *"built from the scoping study, the literature and discussions within the review team."* The search was carried out by using different combinations of the following groups of keywords: [data, information, knowledge]; [flow, shar*, transfer, exchange]; [supply chain, supply network, supply channel, value chain, logistics]. As an example, one search combined the words information, exchange and supply chain. Through scanning documents by *article title, abstract* and/or *keywords* the search resulted in a total of 477 articles. Each article was examined according to certain inclusion criteria, namely: 1) the article relates to inter-organizational sharing of data, information and/or knowledge in supply chains; and 2) the article applies an empirical research method. Wacker (1998) describes empirical research as using induction methods to arrive at theories by collecting data from external organizations or businesses. Based on an initial scan of the abstracts followed by an in-depth evaluation of the full text the final sample consisted of 82 papers, see Table 3. As revealed by

the numbers, few articles represent the years 2000 – 2004, thus indicating the increased empirical research efforts in the area of information sharing since 2005.

Table 3 - Distribution of identified articles over journals and years

Journal / Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
Decision Sciences								1						1
IJOPM							3	2	1	1	2	1	7	17
IJPDLM								3	2	2	3		1	11
IJPE			1						4	1	2	1	5	14
JBL												1	1	2
JMIS						2	2	1	1				2	8
JOM	1		1					4	2		3		1	12
JSCM								1				1	2	4
MIS Quarterly							1			1			1	3
SCMIJ						1	1		3	1	3	1		10
Total	1	0	2	0	0	3	7	12	13	6	13	5	20	82

In the third and final stage of the systematic review each paper was entered into an Excel database. The database contains a summary of each paper including general information (e.g. title, author, journal, year) and main features such as research method, unit of analysis, definition of information sharing and findings. The 82 articles were then analysed and synthesised in the following steps:

1. Unit of analysis: The unit of analysis identifies the part of the supply chain that was the focus of the research (e.g. one company, dyad, triad, etc.). In other words, did the research actually study a supply chain or a focal company or a dyad? We developed a framework for analysis based on the work of Fabbe-Costes and Jahre (2007), see Table 4. To reflect the complexity of the sample we also added the terms *dyadic* (information sharing between buyer and supplier without differentiating upstream and downstream relationships), *extended downstream* and *extended upstream* (information sharing between more than three parties along the supply chain either upstream or downstream).

Table 4 – Definitions of unit of analysis (based on Fabbe-Costes and Jahre, 2007)

Unit of analysis	Definition	# Firms
Dyadic downstream (DS)	Information sharing between the focal company and its customers	2
Dyadic upstream (US)	Information sharing between the focal company and its suppliers	2
Dyadic	Information sharing between buyer and supplier (without differentiating upstream and downstream relationships, i.e. no specific focal company in the relationship)	2
Limited triadic	Information sharing between the focal company and its customers on the one hand and with its suppliers on the other (i.e. both ways, but separately)	3
Triadic	Information sharing between suppliers – focal company – customers (without differentiating upstream and downstream relationships)	3
Extended	Information sharing between more than three parties along the supply chain, e.g. includes customers' customers, suppliers' suppliers or other stakeholders	>3
Extended downstream or upstream	Information sharing between more than three parties along the supply chain either upstream or downstream	>3

2. Research method: Utilized research methods were analysed in order to define the most commonly used methods in information sharing research as well as when articles are reported. We build on Wacker (1998) who identifies three empirical research methods: 1) experimental design; 2) statistical sampling including survey studies and archival research; and 3) case studies. Based on the sample of articles gathered in the systematic review we further nuanced the results by adding three categories: grounded theory, interview studies and secondary data.
3. Unit of data collection: The unit of data collection identifies where in the supply chain data was collected (e.g. one company, dyad, triad, etc.). In other words, did the researchers actually collect data from all members in a supply chain or only from focal companies or dyads? For each article we thus analysed which members of the supply chain that are included in the data collection. We categorized the unit of data collection as: focal company, dyadic, triadic and extended; i.e., data collected from one company, two companies in a dyadic relationship, or three or more companies in a supply chain. We also did a combined analysis of unit of analysis, research method and unit of data collection.
4. Aspects of information sharing: We examined which of the following aspects of information sharing that were investigated in each article:
   - *Why*: benefits of/reasons to implement information sharing in supply chains
   - *What*: what data, information and knowledge should be shared
   - *How*: the means of facilitating information sharing in supply chains
   - *Antecedents, barriers and drivers*: factors that may prevent or promote the implementation of information sharing in supply chains

Results

The most astounding result of our review is that we could not find any empirical study that could provide evidence of benefits from information sharing in supply chain – if we use Mentzer et al. (2001) definition of a supply chain. In fact, we could only find a limited number of articles that actually research supply chains, despite claiming to do so. The few studies that actually use the supply chain as the unit of analysis and that collect data from all companies in the studied supply chain are case studies. However, these studies do not investigate benefits of information sharing but rather barriers and driving forces. The majority of the research regarding benefits from information sharing is based on surveys of a dyadic relationship. Furthermore, the preponderance of these studies are based on data collected from a focal company. Thus, while we cannot claim that evidence for benefits of information sharing does not exist, we could not find the evidence in our review. In the following section we provide a more detailed description of our results. Table 5 lists the number of published articles for each combination of unit of analysis and unit of data collection. Moving rightwards represents an expanded unit of analysis whereas moving downwards represents an increased unit of data collection. The table also lists the research method.

Table 5 – Unit of data collection and research method versus unit of analysis (UoA)

Data collection point vs. UoA	Dyadic DS	Dyadic US	Dyadic	Limited triadic	Triadic	Extended DS	Extended US	Extended	Total
# firms	2	2	2	3	3	>3	>3	>3	
Focal company	**8**	**19**	**23**	**9**		**1**			**60**
Survey	5	16	23	5					49
Case study	3	1		4					8
Secondary data		2							2
Interview study						1			1
Dyadic	**1**	**3**	**12**	**2**					**18**
Survey			4						4
Case study	1	3	5	1					10
Secondary data				1					1
Experiment			1						1
Archival research			1						1
Grounded theory			1						1
Triadic				**1**	**1**				**2**
Case study				1	1				2
Extended							**1**	**1**	**2**
Case study							1	1	2
Total	9	22	35	12	1	1	1	1	82

Unit of analysis

Regarding the unit of analysis, only four articles apply the triadic or extended supply chain as unit of analysis. In other words, less than 5% of the articles actually use the supply chain as the unit of analysis. An overwhelming majority of the reviewed articles investigate dyads (66 articles) with the "buyer – supplier" dyadic relationship being the predominating unit of analysis. Twelve articles investigate information sharing between a focal company and its customers and suppliers, but with separate flows for each dyad.

Research method

The predominating data collection method in information sharing research is the survey method. As Table 5 indicates, 53 of 82 studies are based on surveys. In other words, 65% of the studies are based on surveys. There is also a trend towards increased application of the survey method. Survey studies are primarily used to investigate dyadic relationships between buyers and suppliers. Only five of the 53 survey studies investigate the limited triadic scope and not a single study focused on the supply chain.

The second most common method is the case study which is used in 22 articles. The application of case studies seems to be declining after a peak in 2008. There is a significant difference between surveys and case studies in terms of unit of analysis. Three of the four articles looking at triadic or extended supply chains are based on case studies. In addition, six out of 12 studies focusing on the limited triadic scope of information sharing have applied the case study research method. Among the remaining articles identified in the literature review three are based on secondary data, while the interview study, the experiment, grounded theory and the archival research method each are represented with one article.

Unit of data collection

The unit of data collection identifies where in the supply chain data was collected (e.g. one company, dyad, triad etc.). Remarkably, we could only find three articles where the researchers collect data from companies in a triad or extended supply chain. The majority of the papers (60) represent studies where the researchers collect data from just one company in the supply chain. 16 of the articles apply the dyadic unit of analysis and collect data from both companies. The remaining three papers apply the limited triadic unit of analysis while collecting dyadic data.

Regarding how data was collected, almost all (49 of 53) survey studies collect data from only one company in the supply chain. As a result these articles capture the focal company's perspective on information sharing even though the unit of analysis typically was for more than one company (primarily dyadic). Most of the papers collecting data beyond the focal company have applied the case study research method (14 out of 22).

Aspects of information sharing in supply chains

Concerning benefits of information sharing, a majority of the articles (56) address the "why" aspect (see Table 6). None of these papers investigate triadic or extended information sharing. Rather the majority study dyadic relationships, primarily from the focal company's perspective, by using survey data and quantitative analysis tools (such as structural equation modelling). Through hypotheses testing several authors conclude that increased information sharing leads to improved performance (see for example

Carr and Kaynak, 2007; Hsu *et al.*, 2008). The positive effect of information sharing on performance is reported to be either direct or mediating exemplified by Nyaga, Whipple, Lynch (2010, p. 101): *"Results show that collaborative activities, such as information sharing, joint relationship effort, and dedicated investments lead to trust and commitment. Trust and commitment, in turn, lead to improved satisfaction and performance."*

These survey study results depend on how accurately each investigated construct is captured. We found that, in general, between two and six indicators are used to operationalize the essence and complexity of the construct. Also the type of indicators varies among the reviewed papers. For instance, Carr and Kaynak (2007) capture information sharing by using three indicators: to which extent the information shared between the focal company and their key supplier is 1) detailed, 2) frequent, and 3) timely enough to meet requirements. Nakano (2009) uses two different indicators to operationalize information sharing: sharing 1) standardized, and 2) customized information with main suppliers/customers. In comparison, Paulraj *et al.* (2008) capture information sharing through six indicators: the focal company shares sensitive information; suppliers are provided with any information that might help them; exchange of information takes place frequently, informally and/or in a timely manner; partners keep each other informed about events or changes that may affect the other party; partners have frequent face-to-face planning/communication; partners exchange performance feedback.

Table 6 - Aspects of information sharing versus unit of analysis (an article may have more than one focus)

Aspects of information sharing vs unit of analysis	Dyadic DS	Dyadic US	Dyadic	Limited triadic	Triadic	Extended DS	Extended US	Extended	Total
# firms	2	2	2	3	3	>3	>3	>3	
Why: benefits of/reasons to implement information sharing	6	15	24	11	0	0	0	0	56
What: what data, information and knowledge should be shared	2	4	4	7	0	1	0	0	18
How: the means of facilitating information sharing	2	6	10	4	0	1	0	0	23
Antecedents, barriers and drivers to information sharing	3	4	6	0	1	0	1	1	16

Opposed to the claimed benefits of increased information sharing in supply chains, some studies tone down the link between increased information sharing and improved performance. For instance, Nakano (2009, p. 84) finds that *"external collaborative forecasting and planning does not have a significant effect on relative logistics and production performance."* Porterfield, Bailey and Evers (2010) observe quantitative data of electronic information sharing between companies and compare with performance. They conclude that *"the positive effects of information exchange are supported but some cautions are identified"* (ibid, p. 451). The authors claim that the effect depends on the position of the firm in the supply chain and advise managers *"to consider the tradeoffs between information exchange that enhances performance and information exchange that allows trading partners to act opportunistically"* (ibid, p. 451). Taylor and Fearne (2006) look at the limited triadic scope of information sharing and

question the claimed benefits gained from electronic sharing of demand data: *"In practice such systems may not be as effective as might be imagined"* (ibid, p. 381).

The focus of what to share with whom was identified in 18 research studies. Various authors conclude that deciding what to share with which supply chain partner depends on the context (e.g. Yigitbasioglu, 2010; Wong *et al.*, 2012). Rather than sharing more with all partners, they recommend adjusting information sharing to certain contingency factors. Yet, recommendations are general and do not specify in detail what should be shared with whom. Further, the focus often is on sharing of demand data and inventory levels (e.g. Yigitbasioglu, 2010). One example of current research is Hill *et al.* (2012) who address the importance of demand related information sharing as a tool to stabilize or "cushion" supply chains. They point out how information sharing can help reduce demand uncertainty and thereby decrease the need for excess capacity and high inventory levels throughout supply chains. A second example is Taylor and Fearne (2006). They apply the limited triadic scope of information sharing and collect data beyond the focal company to conclude that information sharing beyond the dyadic partnerships is scarce: *"… in none of the chains studied was EPOS data transferred further upstream than the retailer's immediate supplier"* (ibid, p. 381).

Twenty-three articles address the third aspect of information sharing – how - by investigating the means of sharing such as ERP systems and *Vendor Managed Inventory*. Most of these papers discuss why information systems should be implemented. One example is provided by Fosso Wamba *et al.* (2008) who conclude that RFID technology allows synchronization of product and information flow which enables *"information sharing among all the supply chain players … but with different levels of information access"* (ibid, p. 626). Several authors also investigate under what circumstances firms should implement information systems (e.g. Grover and Saeed, 2007).

Finally, 16 of the analysed articles focus on antecedents, barriers and/or drivers to information sharing. Three of these apply the supply chain as the unit of analysis and collect triadic or extended data. Capó-Vicedo *et al.* (2011, p. 386) analyse the process of knowledge creation with focus on the conditions and requisites in the specific case of the supply chain formed by small and medium enterprises. They conclude that critical success factors include mutual confidence and a similar way of thinking among supply chain members. Similarly, Bailey and Francis (2008) present case-study-based evidence highlighting that information sharing must be complemented by key socio-technical factors such as trust, shared vision, aligned performance measures and shared benefits among supply chain partners: *"While information transparency is upheld within the demand amplification literature as key components of a seamless supply chain and for dampening of the amplification effect, this case indicates strongly that information sharing alone will not deliver superior order replenishment process performance and that other factors must also be present"* (ibid, p. 11). Holweg and Pil (2008) study three automotive supply chains to identify how changes in supply chain systems require changes of information sharing. They conclude that *"providing information visibility as such is not sufficient. Information and capabilities provided by multiple tiers in the supply chain must be used in an integral fashion as otherwise system-wide performance does not follow"* (ibid, p. 404).

Implications

Empirical Evidence of Benefits of Information Sharing in Supply Chains

The first implication of our study is that we have to question whether empirical evidence for benefits of information sharing in supply chains actually exists. In our review, we could not find any empirical study that could provide evidence of benefits from information sharing in supply chains. As we conducted our analysis in several steps, we searched for articles that met the following criteria: 1) apply the supply chain as the unit of analysis, 2) apply the supply chain as the unit of data collection (i.e. collect data from three or more different companies), and 3) investigate benefits related to information sharing. We did not find any articles that met these criteria. We cannot claim that evidence of benefits does not exist, but we can claim that we could not find any evidence.

Rather, the main body of information sharing literature reports on a focal company's perspective on buyer-supplier relationships. In other words, the unit of analysis includes two companies while the unit of data collection only includes one company. An implication of the dominating focus on dyads is that researchers lack the full picture of information sharing in supply chains. It is therefore difficult to draw conclusions and make recommendations to practitioners about benefits of information sharing between three or more companies. This finding is corroborated by Giunipero *et al.* (2008, p. 81), who calls for research applying a unit of analysis beyond the dyadic relationships in supply chains *"… to generate much needed conceptual and empirical work in the SCM literature, thereby creating a body of literature that is more heavily influenced by a deeper analysis of the supply chain on a chain wide or network basis as opposed to the more popular dyadic studies."*

Terminology of Information Sharing in Supply Chains

The second implication of our study is that we must better define the terminology of information sharing in supply chains, ideally also leading to a better structure of the research in the area. One example highlighting the importance of a common terminology is the way survey studies operationalize the essence and complexity of the construct. In the reviewed articles we found a large variety in number and type of indicators. The reason for different ways of operationalizing information sharing in supply chains may be related to the different and sometimes conflicting ways that the term information sharing has been defined. The implication is that using and comparing results from these different studies becomes difficult and loses value. Therefore, streamlining the terminology is a critical step in order to both structure and to expand the research on information sharing in supply chains.

Predominant Methodology for Research Regarding Information Sharing in Supply Chains

The third implication of our study is that we have to consider how we investigate information sharing in supply chains. A requirement of research in an applied field such as supply chain management is often stated as the need to be both relevant and rigorous. Our analysis revealed that the claimed benefits on the dyadic level mainly rely on survey data. Surveys are used in 65% of the reviewed articles and compared to other research methods the trend indicates an increased application of surveys. A majority of the survey studies focus on buyer-supplier relationship limiting the unit of data collection to the focal

company. One explanation for this limitation could be the difficulty in capturing the perspectives of several organizations and individuals interacting in a complex and dynamic supply chain environment. This notion is supported by Cassell and Symon (2004, p. 324), who argue that "*there will always be too many 'variables' for the number of observations made and so the application of standard experimental or survey designs and criteria is not appropriate."* Secondly, gathering complete data representing a dyad can be a complex task to undertake. Li *et al.* (2012, p. 409) comment that *"a significant challenge for studying inter-firm collaboration is that information is difficult to collect and match as pairs."* In survey studies collecting dyadic data (see for example Grover and Saeed, 2007) both companies representing a dyad must respond in order to consider that data for statistical analysis. Extending a survey study beyond one company's perspective to cover two, three or more members of a supply chain may therefore be a challenging task resulting in reduced sample size due to missing values. However, these issues cannot serve as an excuse to claim results beyond what the data can provide.

Focus of Existing Research Regarding Information Sharing in Supply Chains

The fourth implication of our study is that we need to reflect on what aspects of information sharing that we study. Our literature review revealed that only 18 of the 82 identified articles investigate what information to share with various supply chain partners. These studies are primarily focused on dyadic relationships and offer general recommendations rather than specifying in detail what information companies should share and with whom in the supply chain. Further, we found that most research studies focus on demand data and inventory levels. This finding is supported by Klein and Rai (2009) who note that *"past research stresses certain types of information shared between partners, such as information about orders, inventory, or customer demographics"* (ibid, p. 737). An emerging stream in recent years relates to adapting information sharing to the supply chain context (e.g. Kim *et al.*, 2006; Yigitbasioglu, 2010; Caridi *et al.*, 2010). Rather than sharing more with all partners, they recommend adjusting information sharing to certain contingency factors. Yet, Wong *et al.* (2012, p. 167) note that *"prior studies focus on examining what environmental conditions drive the development of information integration, rather than studying how those conditions affect the performance outcomes of information integration."* In summary, our findings imply that there is an opportunity to further explore the "what to share with whom" aspect in supply chains.

Related to the "how" question, most of the 23 identified articles discuss why information systems such as ERP systems and *Vendor Managed Inventory* should be implemented. Another stream of research investigates under what circumstances firms should implement information systems. Finally, 16 articles focus on antecedents, drivers and barriers confirming that to increase performance information sharing alone is not sufficient, but rather depends on several socio-technical factors. It is also interesting to note that all the papers that actually apply the triadic or extended supply chain as unit of analysis address antecedents, barriers and drivers to information sharing in supply chains.

Proposed directions for future research

The current research into information sharing in supply chains can, somewhat simplified, be divided into two categories. The first category constitutes the majority of the research. This category is based on

surveys of a dyadic relationship, yet data is only collected from a focal company. The second category, which is significantly smaller, uses the supply chain as the unit of analysis and collects data from all companies in the studied supply chain. This category is currently based on case study research. However, these studies do not investigate benefits of information sharing, but rather barriers and driving forces. There is, in other words, a significant opportunity to research information sharing in supply chains using a variety of methods to capture this complex phenomenon.

We therefore suggest a research agenda building on four key points: First, we propose more empirically based research applying the supply chain as unit of analysis. We also recommend increasing the unit of data collection to get a multi-dimensional perspective of information sharing. Second, there is a need to further streamline and structure the terminology of information sharing in order to better define metrics for the benefits of information sharing in supply chains. Third, we recommend adopting the case study research method to facilitate the investigation of information sharing between two, three or more companies. Fourth, future research should investigate different aspects of information sharing to answer why, what, how and with whom to share information on a supply chain level. The following sections expand on these ideas.

1. More empirically based research applying the supply chain as the unit of analysis and data collection: Most of the findings and recommendations presented on information sharing result from studying dyadic relationships. The main body of literature reports on buyer-supplier relationships from one focal company's perspective, whereas benefits of information sharing are claimed on a supply chain level (e.g. Meixell and Gargeya, 2005; Giunipero, 2008). To counter this problem, we propose three actions: first, future research studies should state the unit of analysis to avoid confusion and clearly link what is being studied with conclusions and recommendations for information sharing. Second, to support the claims of how increased information sharing leads to increased performance for supply chain members, it is necessary to extend the unit of analysis to cover three or more tiers in supply chains. Third, the majority of information sharing research has limited the unit of data collection to the focal company. Thereby, only one perspective of information sharing in supply chains is captured. To obtain a more nuanced picture and investigate information sharing from different perspectives we propose to expand the unit of data collection in future studies. In combination with increasing the unit of analysis, it will be possible to gather empirical data to support the claims made concerning information sharing in supply chains. This recommendation is supported by Choi and Liker (2002, p. 202), who argue that *"It is certainly easier to get data on dyadic relationships, but the more challenging and perhaps more interesting questions involve longer supply chains. This is where key systems dynamics will be revealed."*

2. Define terminology and metrics for information sharing in supply chains: Key performance indicators or metrics are needed to support claimed benefits of increased information sharing. This will also require that the terminology is structured and defined. The highlighted problem with constructs/indicators in surveys may partly stem from the lack of clear terminology and definitions of information sharing. As a first important step we have defined information sharing in supply chains as the *"inter-organizational sharing of data, information and/or knowledge in supply chains."*

3. Adopt the case study research method to facilitate the investigation of information sharing in supply chains: Previous research studies have reported problems when using surveys to capture the perspectives of two or more members of a supply chain. Therefore, expanding the unit of analysis and/or the unit of data collection may require the application of other research methods. In our literature review we found that the case study is preferred both to look at triadic and extended supply chains as well as for collecting data beyond the focal company. An explanation, as argued by several authors, is that the case study is a suitable research method to investigate and understand the complex nature of information sharing in supply chains involving three or more organizations as well as several individuals operating within the different companies (Ellram, 1996; Yin, 2003; Cassell and Symon, 2004). Cassell and Symon (2004, p. 323) note that the case study is particularly useful when *"the phenomenon is not isolated from its context … but is of interest precisely because the aim is to understand how behavior and/or processes are influenced by, and influence context."* Further, by combining different data collection methods in a case study, it may be possible to get a nuanced picture of information sharing in supply chains and to uncover novel insights into the studied phenomena.

4. Investigate various aspects of information sharing in supply chains: Focusing on the triadic and extended unit of analysis and data collection revealed an opportunity for research to further explore what companies should share with which partners in the supply chain to reap benefits while mitigating risks and costs. To provide new angles of addressing different information sharing aspects, a variety of theories can be used depending on the research study focus. For instance, Transaction Cost Economics and Resource Based View could be useful to understand drivers and barriers to implementing information sharing. To address aspects such as *what to share with whom*, several authors have explored the applicability of contingency theory (e.g. Kim *et al.*, 2006; Yigitbasioglu, 2010; Caridi *et al.*, 2010; Danese, 2011). Contingency theory is not a universalistic theory, meaning that it does not prescribe one best way to organize. Maximum performance is a result of adopting, rather than maximizing, a structural variable to the contingencies. Therefore, the optimal level of any structural variable is unlikely the maximum, and which level is optimal depends on the level of the contingency variable (e.g. Donaldson, 2001). Thus future research applying contingency theory may help organizations to develop models to facilitate decisions as of levels of information sharing, what information to share with whom, as well as what not to share with different supply chain partners.

Concluding discussion

Research in the applied field of supply chain management is often characterized as young, evolving and dynamic. However, neither of these characteristics can serve as an excuse for lack of rigor or relevance in the research. To claim that information sharing in supply chains is beneficial to supply chain members one would expect empirical research to support such statements. However, not only could we not find any such empirical evidence but our results indicate a disconnect between what is being researched, the concluded benefits of information sharing in supply chains, and what is recommended to supply chain managers. One reason is the problems with unit of analysis and unit of data collection. Aspects of information sharing are often researched on the dyadic and not the supply chain level. Similarly, the unit of data collection is frequently limited to one company. Thus, many of the claimed benefits of information sharing among supply chain partners lack underlying empirical proof. Only by collecting the

empirical evidence can the claims of benefits of information sharing in supply chains be supported. Thus, contrary to popular belief, there is still significant need for more research regarding information sharing in supply chains.

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Theoretical perspectives on information sharing in supply chains: A systematic literature review and conceptual framework

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Abstract

Purpose

The purpose of this paper is to explore what theoretical lenses have been used to analyze and understand information sharing in supply chains. The paper elaborate on the predominant theories and discuss how they can be integrated to research different aspects of information sharing.

Design/methodology/approach

The paper carried out a structured literature review by using a combination of selected keywords to search for peer-reviewed articles in ten journals.

Findings

The findings suggest that four out of ten reviewed articles explicitly apply one or more theoretical lenses. The predominant theories used include transaction cost economics, contingency theory, resource based view, resource dependency theory and relational governance theories such as the relational view and social exchange theory.

Research implications

These theories can be applied to analyze different aspects of information sharing. By using the theories in a complementary way it is possible to increase our understanding of information sharing between companies related to: why and what information to share with whom, how to share and the impact of antecedents, barriers and drivers.

Managerial implications

From a managerial perspective, our results highlight the importance of tailoring information sharing structures and governance mechanisms to the context of the transaction and the business relationship.

Originality/value

This paper addresses how theoretical perspectives inform empirical research on information sharing in supply chains. It puts forward an integrative conceptual framework based on cross-disciplinary theories and makes specific suggestions for future empirical research in this area.

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Keywords: Supply chain management, supply chain, information sharing, literature review, theoretical perspectives

Introduction

Information sharing in supply chains has been on the research agenda for several decades and continues to receive attention both from researchers and practitioners (e.g. Forrester, 1958; Cooper *et al.*, 1997; Yu *et al.*, 2010). Information is a key construct of supply chain management (SCM) and represents one of the three flows that needs to be integrated to achieve effective supply chain integration (Sahin and Robinson, 2002) and improve the performance of supply chains (Lee and Wang, 2000; Mentzer *et al*., 2001; Li *et al*., 2006). The utility of information sharing has been long debated in the academic literature. Some studies stress tangible benefits such as reduced inventory levels (e.g. Seidmann and Sundararajan, 1998; Lee *et al*., 2000; Premus and Sanders 2008) while others highlight limitations in terms of accrued risks and costs of sharing information among parties in the supply chain (Uzzi and Lancaster 2003; Samaddar *et al*., 2006; Roh *et al*., 2008; Vanpoucke *et al*., 2009).

The importance of information sharing in supply chains as a research topic is shown by the continuously growing stream of related literature (Sahin and Robinson, 2002; Cousins *et al*., 2006). According to Cousins *et al*. (2006, p. 699), this increase *"has been accompanied by research across a range of academic disciplines, with each discipline making use of its own theoretical lens"*. Yet, we seem to lack an integrative framework to make sense of the varying research findings. Particularly, there is a lack of classification frameworks considering theoretical perspectives (see e.g. Sahin and Robinson, 2002; Huang *et al*., 2003). Theoretical perspectives are important, however, since they can improve the description, explanation and predictions of complex phenomena (Halldorson and Aastrup, 2007; Carter and Rogers, 2008; Defee *et al*., 2010) such as information sharing in supply chains.

To develop a theory-based framework it is necessary to review theories that have been applied in the research on information sharing in supply chains. Such reviews have been conducted within the fields of supply chain integration (SCI) and SCM. From the perspective of SCI, Leuschner *et al*. (2013) highlight the resource based view (RBV) as well as the related resource-advantage theory and the relational view of the firm. Within the field of SCM, Defee *et al*. (2010) identified 181 applied theories with only a handful accounting for the majority of employed theoretical frames. More specifically, transaction cost economics (TCE) and the resource based view account for almost 20% of all theory-informed studies. Similar reviews of theories have not been done in the research area of information sharing in supply chains. We aim to bridge this gap and conduct a systematic literature review to identify what theories have been employed in previous research on information sharing in supply chains. This paper seeks to answer the following research question: *What are the predominant theoretical perspectives to be integrated into a conceptual framework for classifying and evaluating cross-disciplinary empirical research on information sharing in supply chains?*

We seek to explore which theories have been used and how i.e. in terms of key aspects and themes brought forward by these perspectives. Based on the systematic review we develop a conceptual framework of information sharing in supply chains, highlighting and classifying key themes as well as pointing at areas that require further development. On that basis, we provide suggestions for theory-driven, empirical research on information sharing in supply chains. It is envisaged that the framework will inform future empirical studies on the various aspects of information sharing in supply chains, with particular emphasis on information sharing among three or more tiers in the supply chain. Our attention to empirical investigations in the extended supply chain is driven by the current lack of such research initiatives (Kembro and Näslund, 2014).

The term information sharing has been used in many different ways (compare, for instance, Mohr and Spekman, 1994 with Wadhwa and Saxena, 2007), but, in this paper, is used to convey the exchange of data, information and/or knowledge among independent organizations. For the purpose of this study we refer to a supply chain as *"a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer"* (Mentzer *et al*., 2001, p. 4).

The rest of the paper is structured as follows: The next chapter describes and justifies the research methodology. In the third section we present the results of the structured review, including identified aspects of information sharing in supply chains and applied theoretical perspectives. The fourth section presents and discusses the developed conceptual framework. Following the discussion, we conclude by suggesting directions for future empirical research on information sharing in supply chains.

Methodology

We conducted a systematic literature review to ensure research rigor and replicability of the study. Initially we carried out a scoping study which helped to identify the need for this literature review, as elaborated upon in the introduction. We then set up a review protocol refining the research question and defining the search strategy of the literature review including criteria for inclusion and exclusion, in line with recommendations provided by Tranfield *et al*. (2003).

To build on previous literature reviews in the research field (Sahin and Robinson, 2002; Huang *et al*., 2003) and identify contemporary research, we focused on the years 2000 – 2012 and included 10 recognized journals in the review, see Table 1. The search included peer-reviewed articles and was facilitated by employing two databases: Thomson Reuters (formerly ISI) Web of Knowledge and SciVerse Scopus. Journal selection was based on three criteria: First, journals that we found are well represented in previous literature reviews on information sharing in supply chains. Second, journals that include empirical research articles and are well represented in the fields of supply chain management (SCM), operations management (OM), operations research (OR) and management information systems (MIS). Third, we analyzed the ranking of journals in related fields as listed in the Harzing Journal Quality List (http://www.harzing.com/jql.htm).

Table 1 - Journals included in the literature review

Journal
Supply Chain Management, An International Journal (SCMIJ)
Journal of Supply Chain Management (JSCM)
International Journal of Physical Distribution and Logistics Management (IJPDLM)
Journal of Operations Management (JOM)
Journal of Business Logistics (JBL)
International Journal of Operations and Production Management (IJOPM)
Decision Science (DS)
International Journal of Production Economics (IJPE)
Management Information Systems Quarterly (MIS Quarterly)
Journal of Management Information Systems (JMIS)

Along the lines of Tranfield *et al*. (2003, p. 215) the keywords applied in the search emerged through the scoping study by reviewing literature and discussing within the review team. The search included various combinations of the following groups: [data, information, knowledge]; [flow, shar*, transfer, exchange]; [supply chain, supply network, supply channel, value chain, logistics], see Table 2. By scanning documents by article title, abstract and/or keywords the search resulted in a total of 477 articles. By removing duplicates, the sample was reduced to 451. To further narrow down the sample the abstract of each article was examined by using the following inclusion criteria:

- Article must be written in English;
- Abstract must demonstrate inter-organizational information sharing in supply chains as the clear focus/objective of the research;
- Article applies an empirical research method as described by Wacker (1998).

We thus excluded papers that 1) were not written in English; 2) had a focus limited to the intra-firm perspective; and/or 3) employed analytical research methods as described by Wacker (1998). In some cases the abstract did not clarify if the paper fulfilled the inclusion criteria. Those papers were kept for further analysis. In summary, 339 of the 451 articles were removed from the database leaving a sample of 107 empirical research papers.

Table 2 – Keywords and search terms used in the systematic review

[data] or [information] or [knowledge]	AND	[flow] or [shar*] or [transfer] or [exchange]	AND	[supply chain] or [supply network] or [supply channel] or [value chain] or [logistics]
Example of combination: "information" AND "exchange" AND "supply chain"				

In the next step an in-depth examination of the full text of the remaining 107 papers was carried out. As a result, applying the previously mentioned inclusion/exclusion criteria, 25 articles proved to have limited relevance in relation to the aim of this research study. The final sample thus consisted of 82 papers, each entered into an Excel database. To enable structured examination and review of the papers, data extraction sheets (Tranfield *et al*., 2003) were devised corresponding to the columns included in the excel database. The database contains a summary of each paper including general publication details (title, author, journal and year of publication) as well as main elements relevant for this study, namely: purpose of the study, definition of information sharing, key study findings, theoretical perspective(s), aspects of information sharing and unit of analysis, see Appendix I. With regard to theoretical perspective(s) and aspects of information sharing we did not pre-define the classification schemes. Instead, we let the data guide us and had classification schemes emerge through the literature review. For the category “unit of analysis”, we based the pre-defined classification scheme (“dyadic”, “triadic”, and “extended”) on the work of Fabbe-Costes and Jahre (2007). The unit of analysis identifies the part of the supply chain that was the focus of the research. Dyadic thus signifies two companies representing two tiers in a supply chain; triadic denotes companies from three tiers and extended more than three tiers in a supply chain.

The assessment and classification of papers guided the analysis of 1) how often and which theoretical perspectives are actually drawn upon to study information sharing in supply chains; 2) which level of analysis these theories refer to; and 3) how they have been employed to address the various aspects of information sharing in supply chains. Such analysis and synthesis provided input for developing a conceptual framework integrating identified themes and aspects of information sharing in supply chains.

Findings of the systematic review

This section presents the findings of the systematic literature review in terms of identified aspects of information sharing in supply chains and employed theoretical perspectives. We elaborate on the pre-dominant theories to understand how they can be used to investigate and understand information sharing in supply chains.

Aspects of information sharing in supply chains

Through the literature review we identified four themes or aspects of information sharing in supply chains, namely: 1) why (not) share information; 2) what information to share with whom; 3) how to share information; and 4) pre-requisites, barriers and drivers.

Why (not) share

A total of 36 papers in the review address the “why” aspect of information sharing. Research often suggests that information sharing leads to improved performance in supply chains (e.g. Vereecke and Muylle, 2006; Carr and Kaynak, 2007; Hsu *et al.*, 2008; Prajogo and Olhager, 2011). The positive effect of information sharing on performance can be either direct or mediating, for example: *“Results show that collaborative activities, such as information sharing, joint relationship effort, and dedicated investments lead to trust and commitment. Trust and commitment, in turn, lead to improved satisfaction and performance”* (Nyaga *et al.*, 2010, p. 101). Proposed benefits range from relatively immediate and concrete aspects, such as improved forecasts and reduced inventory levels (Lee *et al.*, 2000), to more long term potential benefits. In the long run, information sharing facilitates coordination of processes which could lead to improved long-term relationships. Similarly, information sharing may create value via enhanced planning and decision making processes in the supply chain (Sahin and Robinson, 2002;

Premus and Sanders, 2008). Despite the potential benefits, information sharing is associated with certain risks and costs which may discourage organizations to share information with their supply chain partners. The risks of losing a competitive advantage and bargaining power through sharing valuable information and knowledge are ever present (Uzzi and Lancaster, 2003; Seidmann and Sundararajan 1998). Setting up and maintaining information sharing mechanisms and infrastructure (e.g. information systems) entails significant resource investments which could result in a negative cost-benefit analysis (Vanpoucke *et al.*, 2009). Additionally, resulting benefits of information sharing may be difficult to allocate in a fair way among supply chain partners (Lee and Whang, 2000).

What to share with whom

The claimed benefits can be realized by sharing information at different organizational levels between members in the supply chain (e.g. Taylor and Fearne, 2006). Partners could, for example, share forecasts, trends and plans to sustain and enhance company as well as supply chain competitiveness (Yigitbasioglu, 2010). Similarly, information regarding performance indicators, operations, planning and financial information can be shared to synchronize operations; reduce costs and improve responsiveness (Premus and Sanders, 2008). Information sharing occurs between two or more members in a supply chain. It is necessary for companies to understand which relationships should be managed at arm's length and which ones should be moved into a more partnership style (Cooper *et al*., 1997). Various authors argue that deciding what to share with which supply chain partner depends on the context (Kim *et al*., 2006; Caridi *et al*., 2010; Yigitbasioglu, 2010). Rather than sharing more information with all partners, they recommend adjusting information sharing to certain contingency factors.

How to share

There is a wide range of information sharing means, such as face-to-face contact, telephone and fax as well as email, EDI, web-enabled portals, enterprise resource planning and data warehouse management (e.g. Hill and Scudder, 2002; Stefansson, 2002; Adewole, 2005). Sharing information upstream and downstream the supply chain can be facilitated by the use of internet e.g. in the grocery industry which primarily includes the supply of functional products, predictable demand and stable supply processes (Lee, 2002). The capacity to manage information sharing across the supply chain has been significantly enhanced by the technological advances. However, to build, implement and integrate electronic transmission in supply chains requires large investments, and practitioners often believe that certain information sharing is better off by face-to-face contact. It is therefore critical to determine the specific means of sharing for each piece of information and establish the proper exchange architecture (Hill and Scudder, 2002; Adewole, 2005; Rai *et al*., 2012; Tallon, 2012).

Prerequisites, barriers and drivers

To accurately address and implement information sharing, several authors argue that it is necessary to also understand the impact of prerequisites (commonly referred to as antecedents), barriers and drivers of information sharing in supply chains (e.g. Bailey and Francis, 2008; Hernandez-Espallardo *et al*., 2010; Capo-Vicedo *et al*., 2011). Prerequisites represent factors that must be in place for information sharing to take place. These could, for example, include IT infrastructure and information quality. Barriers represent factors that may have a negative impact on the level of information sharing in supply chains. Examples are cost and complexity of implementing advanced systems; existing systems incompatibility; confidentiality of shared information and the risk of partners reaping all the benefits; and the fear of becoming overly dependent on partners who receive the information. Third, drivers denote factors that may enforce the level of information sharing in the supply chain. These include both relational governance mechanisms such as trust and contractual governance through formal controls (e.g. contractual obligation to exchange information) and incentive systems. Additional drivers include dependency on supply chain partners and demand uncertainty (e.g. Patnayakuni *et al*., 2006; Klein and Rai, 2009; Yigitbasioglu, 2010)

Theoretical perspectives employed

The analysis revealed that four out of ten papers (41%) employ at least one theoretical perspective. In total we identified 23 different theories of which only five represent 80% of all theoretical instances[1] in our sample. As

[1] Each paper may represent no, one or more theoretical instances depending on the number of theories employed.

shown in Table 3, the most commonly applied theory is TCE, which has been applied in 17 of the reviewed papers. The same number of studies was identified for "relational governance theories" (RGT). RGT represents six closely related theories social exchange, social capital, social contract, relational exchange and the relational view. These theories are grouped together because they all focus on exchange mechanisms that are manifested in socially derived arrangements (Vandaele *et al*., 2007). The next three frequently applied theories include contingency theory (CT), resource dependency theory (RDT) and resource based view (RBV).

Compared to Defee *et al*. (2010), who analyzed the use of theories in SCM literature, there are some differences worth pointing out. First, Defee *et al*. noted that five out of ten (53.3%) papers in their sample used at least one theory. Research on information sharing in supply chains thus appears to apply theories less frequently. Second, the most important theories in information sharing vary slightly to those in SCM research. Defee *et al*. identified TCE and RBV as substantially more popular than other theories. In our review, TCE also is the most frequently used. However, other theories are more frequently applied than RBV. An explanation may be that the RBV of the firm, in its original version at least, focuses on within-firm resources (including knowledge and information) and is not as useful to study exchange relationships and more specifically inter-organizational information sharing.

Table 3 also reveals an increased application of theories in recent years. Particularly, our findings show a growing importance and use of theories having their origins in sociology (e.g. social capital and social exchange theory) to emphasize inter-personal and relational dimensions of information sharing in supply chains (e.g. Grover and Saeed, 2007; Klein and Rai, 2009; Bastl and Johnson, 2012). Also, CT is increasingly used acknowledging that there is no universal solution how to approach information sharing in a supply chain. Instead, information sharing should be adapted to the specific supply chain context (e.g. Kim *et al*., 2006; Caridi *et al*., 2010; Wong *et al*., 2012).

Table 3 - Theoretical lenses applied per year

Theoretical lenses applied vs. Year	2000 - 2004	2005	2006	2007	2008	2009	2010	2011	2012	Total	% of total	Cumul-ative % of total
Transaction Cost Economics		1	2	2	1		7		4	17	25.8%	25.8%
Relational governance theories (including Relational View, Social Exchange Theory, Relational Exchange Theory, Social Contract Theory, Social Capital Theory)		1	1	2	1	1	4		7	17	25.8%	51.5%
Contingency Theory (including Information Processing Theory and Configuration Theory)	1	1	1	1			2		2	8	12.1%	63.6%
Resource Dependency Theory			1	1			3		2	7	10.6%	74.2%
Resource Based View					1		3			4	6.1%	80.3%
Knowledge Based View				2						2	3.0%	83.3%
Adaptive Structuration Theory					1					1	1.5%	84.8%
Capability-based Perspective									1	1	1.5%	86.4%
Complex Adaptive Systems					1					1	1.5%	87.9%
Goal Congruence Theory									1	1	1.5%	89.4%
Industrial Dynamics			1							1	1.5%	90.9%
Interdependence Theory							1			1	1.5%	92.4%
Institutional Theory							1			1	1.5%	93.9%
Organizational Learning				1						1	1.5%	95.5%
Social Network Analysis								1		1	1.5%	97.0%
Socio-Technical Systems				1						1	1.5%	98.5%
Stakeholder Theory				1						1	1.5%	100.0%
Total	**1**	**3**	**6**	**11**	**5**	**1**	**21**	**1**	**17**	**66**	**100%**	

Theoretical perspectives vs. unit of analysis

Table 4 suggests that empirical research on information sharing is heavily focused on the level of dyadic supply chain relationships (i.e. between buyer and supplier). In particular, 66 out of the 82 reviewed papers apply the dyad as their analytical unit. Regarding applied theories, the emphasis on dyads is even stronger: 60 out of the 66 theoretical instances stress the dyadic level. In particular, all papers applying TCE, RGT and RDT focus on information sharing in dyadic relationships.

Moving beyond the dyad, thirteen papers investigate information sharing among three-tiers in the supply chain (e.g. Holweg and Pil, 2008; Caridi *et al*., 2010). Only four of the identified theories are used to examine information sharing across three-tiers in the supply chain. These include CT, the RBV (in its extended form, see below), complex adaptive systems and adaptive structuration theory. Only three papers in our sample (Bailey and Francis, 2008; Pedroso and Nakano, 2009; Capo-Vicedo *et al*., 2011) examine information sharing in the extended supply chain. This is perhaps not a surprising finding given the methodological challenges related to access and data collection across multiple connected organizations in a supply chain (Cassell and Symon, 2004; Li *et al*., 2012). The only theory-informed study applying the extended supply chain as unit of analysis is conducted by Capó-Vicedo *et al*. (2011): they employ social network analysis to investigate the knowledge generation process in a multi-level supply chain formed by small and medium-sized enterprises in the construction sector. To foster the creation and sharing of knowledge among partners, the authors stress the importance of collaboration and urge companies to nurture mutual confidence.

Table 4 - Theoretical lenses applied vs. unit of analysis

Theoretical lenses applied vs. unit of analysis	Dyadic	Triadic	Extended	Total
Transaction Cost Economics	17	0	0	17
Relational governance theories (including Relational View, Social Exchange Theory, Relational Exchange Theory, Social Contract Theory, Social Capital Theory)	17	0	0	17
Contingency Theory (including Information Processing Theory and Configuration Theory)	6	2	0	8
Resource Dependency Theory	7	0	0	7
Resource Based View	3	1	0	4
Knowledge Based View	2	0	0	2
Adaptive Structuration Theory	0	1	0	1
Capability-based Perspective	1	0	0	1
Complex Adaptive Systems	0	1	0	1
Goal Congruence Theory	1	0	0	1
Industrial Dynamics	1	0	0	1
Interdependence Theory	1	0	0	1
Institutional Theory	1	0	0	1
Organizational Learning	1	0	0	1
Social Network Analysis	0	0	1	1
Socio-Technical Systems	1	0	0	1
Stakeholder Theory	1	0	0	1
Total no. of theories applied	60	5	1	66
Total no. of papers reviewed	66	13	3	82

Theoretical perspectives vs. aspects of information sharing

Table 5 provides an overview of how different theories have been used to investigate different aspects of information sharing in supply chains. The most researched aspects include "why (not) share" (e.g. Paulraj *et al.*, 2008; Wong *et al.*, 2012) and "pre-requisites, barriers and drivers" (e.g. Vijayasarathy, 2010). In addition, 17 papers investigate the aspect of "how to share" information (e.g. Hadaya and Pellerin, 2010), whereas twelve studies address "what information to share with whom" in the supply chain (e.g. Porterfield *et al.*, 2010). Focusing on the pre-dominant theories (in descending order: TCE, RGT, CT, RDT and RBV) one observation is that each of these theories have been used to study different aspects of information sharing. At the same time, each aspect has been investigated using several of the theoretical perspectives.

In the following sections each of the five pre-dominant theories will be discussed. Each theory is presented with a brief introduction including its main assumptions and predictions. Thereafter, we present the findings from the literature review in terms of how and why the theory has been used to investigate information sharing in supply chains. These findings are then summarized in Table 6 to provide an overview of the connections between the theories and the different information sharing aspects.

Table 5 - Theoretical lenses applied versus aspect of information sharing in supply chains

Theoretical lenses applied vs. aspects of information sharing in supply chains	Why (not) share	What to share with whom	How to share	Pre-requisites, barriers & drivers
Transaction Cost Economics	8	4	5	4
Relational governance theories (including Relational View, Social Exchange Theory, Relational Exchange Theory, Social Contract Theory, Social Capital Theory)	12	2	3	5
Contingency Theory (including Information Processing Theory and Configuration Theory)	7	4	2	
Resource Dependency Theory	4	1	2	3
Resource Based View	1		1	3
Knowledge Based View	1		1	
Adaptive Structuration Theory				1
Capability-based Perspective	1			
Complex Adaptive Systems				1
Goal Congruence Theory	1			
Industrial Dynamics	1	1		
Interdependence Theory				1
Institutional Theory				1
Organizational Learning			1	
Social Network Analysis				1
Socio-Technical Systems			1	
Stakeholder Theory			1	
Total	36	12	17	20

Transaction Cost Economics

TCE deals with the governance of economic transactions (Williamson 1985). Economic transactions incur costs which may differ between different modes of production coordination (Coase 1937; Williamson and Masten 1999). An assumption of TCE is that actors act opportunistically in light of bounded rationality and information asymmetry. One way to mitigate the perceived risks of opportunism is to establish formal contracts safeguarding asset-specific

investments (Williamson 1985). Contracts could, however, also serve as broad frameworks that leave room for *ex post* adjustment of investments and efforts (Ménard and Valceschini, 2005). TCE can thus be useful to understand why organizations in the supply chain share information, how contracts are used to do so and what drives or inhibits such behavior (e.g. Rindfleisch and Heide 1997; Seidmann and Sundararajan, 1998).

The systematic literature review supports the view that TCE is useful for investigating different aspects of information sharing in supply chains. First, by implementing new means of sharing information it is possible to improve information processing capabilities and thereby reduce uncertainty and transaction costs (see e.g. Tan *et al*., 2010). Second, there are several reasons why firms may decide to withhold information from supply chain partners. Firms may want to manage the behaviors of their partners (Kim *et al*., 2006) and avoid being exploited themselves. For instance, firms sharing their inventory levels as well as information on their demand patterns and marketing strategies run the risk of losing volume discounts that would otherwise be offered (Klein and Rei, 2009). Another example is provided by Yigitbasioglu (2010) who suggests that firms might withhold information in the development and/or growth stage of the product life cycle to avoid opportunistic partner behavior. Viewing information as a valuable asset that should be protected may also explain why certain companies avoid investing in relation-specific information technology systems (Tan *et al*., 2010; Klein *et al*., 2007).

Third, TCE may help to understand what information to share with which partner and how. The characteristics of the transaction (e.g. degree of demand uncertainty) impact the required intensity of information sharing (Yigitbasioglu, 2010). Fourth, TCE suggest ways to govern information sharing by both compensating partners and preventing opportunistic behavior. More specifically, firms should consider establishing formal contracts including incentives and/or penalties to enable efficient information sharing (Grover and Saeed, 2007; Porterfield *et al*., 2010). However, TCE underplays the role of extra-contractual mechanisms and norms that are equally important to govern supply chain relationships (Klein Woolthuis *et al*., 2005; Klein *et al*., 2007). It also has limited explanatory power with regards to value creation and generation of rents through collaboration and sharing of resources and capabilities among organizations in the supply chain (Gomes and Dahab, 2010).

Relational governance theories

To address the limitations of TCE, there is a trend towards increased application of RGT (see Table 3). Paulraj and Chen (2007) note that companies increasingly emphasize working closely and co-operatively with a limited number of trustworthy suppliers. Therefore, relational governance theories such as relational exchange theory are appropriate to study strategic buyer-supplier relationships. Relational governance involves two or more partners that become mutually reliant and employ informal mechanisms (e.g. based on social controls) to govern the relationship (Patnayakuni *et al*., 2006). Such ties would hold the exchange relationship together as long as each partner perceives that they are better off by continuing the agreement than ending it (Nyaga *et al*., 2010). An underlying assumption is that trust, rather than opportunistic behavior, guides inter-personal and inter-firm relationships (Kim *et al*., 2006).

RGT helps understanding why supply chain partners should engage in information sharing by stressing its benefits in terms of increased cooperation, as compared to cases where exchange parties may withhold information (Klein and Rai, 2009). For instance, social exchange theory emphasizes reciprocated benefits which promote information sharing on the expectation of mutual gains (Nyaga *et al*., 2010). This perspective helps to explain how social exchanges and norms can improve inter-organizational cooperation, which could lead to enhanced operational efficiencies (Wei *et al*., 2012). In a similar vein, the relational view is used to understand how inter-firm relationships can create relational value including relationship-specific assets, knowledge-sharing routines, complementary resources and capabilities as well as effective governance (Rai *et al*., 2012).

RGT is also useful to determine what information to share with whom and how. From the perspective of social contracting theory, exchange activities such as information sharing are assumed to be embedded in a social context. The social context of the relationship is proposed as the main source of the exchange needs. This context also impacts the choice of information sharing and governance mechanisms for coordinating and controlling the inter-organizational exchanges (Grover and Saeed, 2007).

Contingency Theory

Originating from organic and bureaucracy theory, CT recognizes that there is no one best way to design an organization. Organizations should instead match structures and processes to the internal and external environment (Woodward, 1965; Lawrence and Lorsch, 1967; Thompson, 1967; Galbraith, 1974; Persson 1978, 1995; Donaldson, 2001; Butterman *et al*., 2008; Flynn *et al*., 2010). By sharing information under favorable environmental conditions, CT predicts that organizations improve their ability to perform (Wong *et al*., 2012). In contrast, sharing information under unfavorable conditions may lead to partners suffering from excessive information sharing which could cause delayed or inappropriate decisions. Unfavorable conditions include supply chains of products that are simple in technical terms and represent stable demand patterns (Kim *et al*., 2006).

According to CT, companies can identify the appropriate level and scope of information sharing by considering the supply chain context. In other words, firms can decide what information to share with which partner to minimize the risk that organizational resources are wasted without enhancing the supply chain performance and not satisfying customers' needs (e.g. Vanpoucke *et al*., 2009; Wong *et al*., 2012). The supply chain context can be characterized by supply chain structure (Samaddar *et al*., 2006), characteristics of partner relationships (Vanpoucke *et al*., 2009), supply uncertainty (Lee, 2002) and customization point (Van der Vaart and van Donk, 2006). Other examples identified in the literature review include Stock *et al*. (2000) who submit that companies should govern their supply chain relationships differently depending on geographic dispersion of partners; and Wong *et al*. (2012) who conclude that information sharing is particularly beneficial in munificent supply chains offering complex products in a less uncertain environment. Similarly, Caridi *et al*. (2010) suggest that complex supply chains require increased visibility. Their findings indicate that focal companies in many cases fail to adapt information sharing to the supply chain context. Particularly, they argue, companies have too little visibility on the suppliers' suppliers.

CT also helps to understand how firms exchange information and what specific information sharing mechanisms are employed to match information processing needs in supply chains. According to Grover and Saeed (2007), organizations would benefit from implementing inter-organizational systems when complexity of the product or component is high and market fragmentation is low. Along the same line, Kim *et al*. (2006) conclude that optimal supply chain performance is a result of matching the information processing capabilities produced by electronic information transfer with the information processing needs generated by the inter-organizational context.

Resource dependency theory

The fourth most commonly applied theoretical lens is RDT. This theory assumes that organizations depend on the external environment for resources and seek alternative ways to get access to these resources while trying to remain autonomous from the other organizations (Donaldson, 2001). Dependency can, in other words, be considered a function of the criticality of the resource and availability of alternative suppliers and/or buyers (Yigitbasioglu, 2010). Similar to CT, RDT predicts that organizational behavior is adapted to the context in which the organization is embedded (Dyer and Singh, 1998).

RDT is useful to understand several aspects of information sharing in supply chains. The theory can help to explain why a company might choose (not) to share information and involve certain supply chain partners because of resource dependency (Patnayakuni *et al*., 2006). Next, firms should decide what information to share with which supply chain partners considering both bilateral dependencies and the level of dependency asymmetry (Vijayasarathy, 2010; Yigitbasioglu, 2010). Bilateral dependence can have a positive influence on willingness and commitment to share information, whereas high dependency asymmetry may be detrimental to exchange relationships and information sharing (Vijayasarathy, 2010).

Dependency asymmetry between companies can also help to explain the adoption of information sharing such as electronic data interchange. Dependency asymmetry may lead to power distribution issues where, for example, one company could impose on another what information sharing mechanisms are required to be implemented (Yigitbasioglu, 2010). Finally, the degree of dependency has an impact on decisions regarding the deployment of governance mechanisms related to information sharing (Grover and Saeed, 2007). By selecting governance mechanism as a strategic response to dependency firms can better manage relationship dependencies in order to reduce uncertainty and dependency related to scarce and valued resources (Tan *et al*., 2010).

Resource Based View

Four of the identified papers apply the RBV as their theoretical lens. The RBV of the firm is one of the dominant theoretical frameworks within strategy literature (Peteraf, 1993; Kim and Mahoney, 2005). It focuses on the firm's internal resources as the primary unit of analysis and suggests that organizations that possess resources that are valuable, rare, inimitable and/or non-substitutable develop and sustain an edge over competitors (Wernerfelt, 1984; Barney, 1991). A corollary of this is that a firm should attempt to protect, rather than share, its valuable and/or unique resources to help generate increased rents (Peteraf, 1993).

According to RBV, information can be considered a valuable resource that can be used to create a competitive advantage in supply chains. RBV is, nonetheless, criticized for its over-emphasis on resources inside the firm and the fact that it underplays rent generation opportunities through inter-organizational information sharing (Barney *et al*., 2011). The findings from the systematic review emphasize the limitation of the focus on only internal resources (see e.g. Holweg and Pil, 2008; Paulraj *et al*., 2008). In line with the extended RBV (Lavie, 2006), it is suggested that a firm's critical resources extend beyond the firm's boundaries and that they can be embedded in inter-firm routines and processes. Thus, information and knowledge sharing across firm boundaries can create relational rents and thus increase the competitiveness of the supply chain as a whole (Patnayakuni *et al*., 2006; Hernández-Espallardo *et al*., 2010).

The extended RBV is useful for explaining why firms may engage into collaborative relationships with supply chain partners to gain access to critical information and knowledge that is missing internally. Joint investments in relationship-specific assets such as electronic data interchange and deployment of effective governance mechanisms may also create relational rents (Tan *et al*., 2010). However, not all information and/or knowledge is equally valuable to protect or share. In other words, a "one-size-fits-all" approach to information sharing in supply chains may be inefficient (Samaddar *et al*., 2006). The RBV and its extended version thus offer a useful theoretical frame to study why firms choose (not) to share information with other parties in the supply chain and what the potential drivers and barriers of doing so are.

Connecting theories with aspects of information sharing

Each of the discussed theories can be used in a complementary fashion to investigate and understand many of the identified aspects of information sharing. In brief, TCE takes a contractual approach to information sharing (or its lack thereof) but appears to underplay the role of relational approaches to inter-firm governance and value creation through information and knowledge sharing. RGT address this deficiency of TCE by stressing relational aspects and the role of the context of social relations in information sharing. CT puts the context at centre stage to study reasons for (not) sharing information in supply chains, what to share with whom, and how. Similarly to CT, RDT emphasizes the context within which decisions are made and focuses on issues such as the impact of bilateral dependencies and dependency asymmetries on information sharing. Finally, resource-based perspectives (RBV and its extended version) also contribute important insights into existing research on information sharing in supply chains by addressing why organization may be protecting or sharing information and knowledge, as well as the drivers of doing so.

Table 6 suggests that each aspect can be explained from the perspective of several of the five pre-dominant theories. The table provides an overview of the findings including indicative example studies. Starting from the leftmost column, the table outlines how TCE, RGT, CT and RBV can be used to understand why supply chain partners would share information with each other. One reason to implement information sharing is to reduce transaction costs (TCE). Another reason is to improve inter-organizational cooperation to improve the operational efficiency (RGT) and secure critical resources that extend beyond the firm boundaries (extended RBV). At the same time, however, investments in inter-organizational information systems could increase dependency (RDT) and allow partners to act opportunistically (TCE). Firms must therefore carefully consider the supply chain context and engage in information sharing initiatives under favorable conditions (CT).

Moving through the table to the rightmost columns, we see that each aspect can be investigated and better understood by applying different theoretical perspectives. As one example, drivers to information sharing have received much attention in the reviewed literature. Particularly, we noted much discussion on how formal and/or

informal contracts may create specific requirements for information sharing in supply chains. Therefore we emphasized and described “governance mechanisms” in a separate column. One approach to govern information sharing is to establish formal contracts including incentives and penalties (TCE). Another approach is to promote mutual trust and reciprocated benefits (RGT) in order to encourage information sharing. In turn, information sharing can facilitate relational alignment which ultimately could be a source for competitive advantage (Tan *et al*., 2010). A third approach is to combine formal and informal contracts into a hybrid governance option. By considering the supply chain context such as uncertainty and dependency (TCE, RDT, CT), hybrid governance may be an option allowing for combinations of contractual and relational mechanisms (Grover and Saeed, 2007; Nyaga *et al*., 2010).

Table 6 - Connecting theories and aspects of information sharing in supply chains

Theories vs Aspects	Why share	Why not	What to share with whom	How to share	Pre-requisites, barriers & drivers	Governance mechanisms
Transaction cost theory	Information sharing with partners can reduce uncertainty and transaction costs (Tan et al., 2010)	Maintain information asymmetry to prevent partners from acting opportunistically (Klein et al., 2007; Yigitbasioglu, 2010)	The characteristics of the transaction (e.g. degree of demand uncertainty) impact the required intensity of information sharing (Yigitbasioglu, 2010)	Implement new means of sharing information (e.g. EDI) to improve information processing capabilities and thereby reduce uncertainty and transaction costs (Tan et al., 2010)	Establish formal contracts to compensate partners and prevent opportunistics behavior through incentives and penalties. (Porterfield et al., 2010)	Select governance structure as a strategic response to uncertainty (Grover and Saeed, 2007)
Relational governance theories (e.g. RV, RET, SET)	Exchange relationships improve inter-organizational cooperation, which could lead to enhanced operational efficiencies (Wei et al., 2012)		The relationship context is proposed as the main source of coordination needs. (Grover and Saeed, 2007)		Suggesting norms of reciprocating benefits such that people cooperate under the expectation that they will give and receive from the relationship (Nyaga et al., 2010)	Select coordination mechanism considering the relationship context as an important dimension of the transaction. (Grover and Saeed, 2007)
Contingency theory (including IPT and configuration theory)	information sharing improves an organization's ability to perform when they operate under favorable environmental conditions. (Wong *et al.*, 2012)	Partners may suffer from excessive information sharing ("information overload") which could cause delayed or inappropriate decisions. (Kim *et al.*, 2006)	Avoid "one-size-fits-all", rather adapt level and scope of information sharing to internal and external environment (Stock et al, 2000; Grover and Saeed, 2007; Caridi et al., 2010)	Adapt information processing capabilities to the supply chain context. (Kim et al., 2006; Grover and Saeed, 2007)		
Resource based view	Engage in collaborative relationships to secure critical resources that extend beyond the firm boundaries. (Patnayakuni et al., 2006; Hernandez-Espallardo et al., 2010)	Increase competitive advantage through protecting firm-specific resources and capabilities. (Holweg and Pil, 2008; Paulraj et al., 2008)		New technologies such as EDI can represent an inimitable resource that may positively affect firm performance (Tan et al., 2010)	Firms lacking certain competitive capabilities will promote collaborative relationships. (Tan et al., 2010)	
Resource dependency theory		Investing in inter-organizational information systems could increases dependency. (Patnayakuni et al., 2006)	Adapt level of information sharing with supply chain partners based on degree of dependency. (Yigitbasioglu, 2010)	Consider information sharing capability of partners when leveraging relationships (in order to reduce uncertainty and dependency related to scarce and valued resources) (Tan *et al*., 2010)	Mutual dependence can have a positive influence on integration and commitment, asymmetrical dependence can be expected to be detrimental to inter-organizational relationships. (Vijayasarathy, 2010)	Select governance structure as a strategic response to dependency. (Grover and Saeed, 2007)

Research implications

The findings of the systematic review present several implications with regards to future development of empirical research on information sharing in supply chains. First, we note that there is ample room for theory building in this research field since six out of ten reviewed papers (59%) apply no theory at all. In the remaining papers various theories have been used to investigate different aspects of information sharing in supply chains, but largely on a piecemeal fashion and without a systematic framework to guide theory-driven research (Sahin and Robinson, 2002).

Second, and in connection to the point above, our findings show that each theory in itself is incomplete (i.e. have limited explanatory power) to investigate and fully understand and explain a complex phenomenon such as information sharing in supply chains. Each of the identified information sharing aspects can be understood by applying different theoretical perspectives. TCE and RDT, for example, each offers an incomplete understanding of the formation of interorganizational relationships including information sharing (Chu and Wang, 2012, p 81): "*TCE's focus on cost and efficiency tends to neglect other important reasons and criteria (e.g., the perceived power of a potential partner) in the formation of an inter-organizational relationship. Conversely, RDT focuses on external resources without considering transaction costs.*" This line of argument leads us to the third implication: the identified theories need not necessarily substitute each other but they may well be viewed as complementary, as discussed in the previous section. For instance, CT, TCE and RGT such as social contracting theory can be employed to understand how firms decide on appropriate information sharing structures and governance mechanisms by considering the context of the transaction and the business relationship (e.g. Grover and Saeed, 2007). In particular, different theories can be used to understand in which contexts formal contracts may be more appropriate than trust building to govern information sharing.

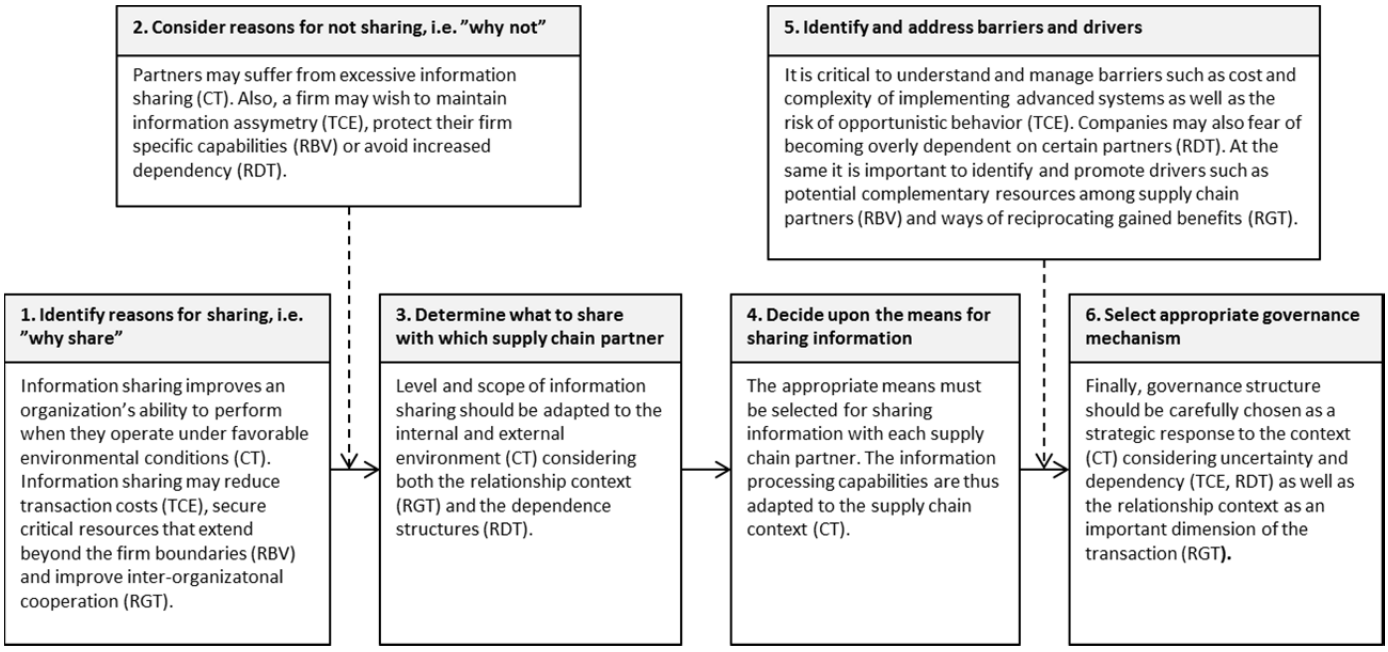
The fourth implication relates to the supply chain context and how this influences information sharing in supply chains, for example, in terms of content and structure (what to share with whom) and appliances (how to share). We note that most, if not all, empirical papers converge into the conclusion that "one size does not fit all". The assumptions and predictions of TCE, RBV, RDT and RGT, in one way or another, all seem to suggest that decisions are (supply chain) context-dependent. For instance, Power and Singh (2007, p 1306) argue that *"context (i.e. contingency theory) may in fact be an underlying pre-condition that needs to be considered for any supply chain-based study looking at relationships between multiple ''integration'' factors."* Considering information sharing as an important construct of supply chain integration, the context may assume a key analytical unit in order to make sense of the relative importance of competing theoretical explanations of information sharing.

Building on these four implications and based on our findings of how different theories have been used to investigate and understand information sharing in supply chains, we propose a conceptual framework (see Figure 1). The purpose of the framework is twofold: a) to classify and map pre-dominant theoretical perspectives that have been used to empirically address different aspects of information sharing in supply chains, and b) to guide future empirical research and theory building by suggesting how different theories can be employed, also in combination, to develop a holistic understanding of information sharing in supply chains.

Based on the identified information sharing aspects, the first step of the framework is to identify reasons for and against sharing ("why (not) share"). For this purpose, the five pre-dominant theories are all relevant to consider. Particularly, CT is important in order to identify favorable conditions for information sharing. Theories such as the RBV and TCE can explain why supply chain actors may abstain from information sharing (second step) due to their intention to protect idiosyncratic information or maintain information advantages over other parties respectively. The third step in the framework is focused on the selection of what information to share with which supply chain partners. In this respect RBV, RDT and RGT are useful, addressing potential resource/capability complementarities, dependency structures and the impact of relational characteristics respectively. In the fourth step, information processing theory (i.e. CT) can help decide the appropriate means for sharing information and the required capabilities to do so. In the fifth step the focus is on identification of potential barriers as well as drivers of information sharing in supply chains. TCE, RDT and RGT are important to consider for understanding and managing barriers such as the risk of opportunism and over-dependency on supply chain partners as well as drivers of

information sharing such as resource complementarities with other supply chain actors. The final step concerns the deployment of appropriate governance mechanism as a driver of information sharing. Analysis of the impact of contractual and/or relational mechanisms on information sharing should consider the context of the transaction including the level of uncertainty and inter-firm dependency, as well as and the characteristics of the exchange relationship at hand.

Figure 1 – A conceptual framework to investigate and understand information sharing in supply chains, considering predictions of respective theory



Managerial implications

From a managerial perspective, our results highlight the importance of understanding and considering the supply chain context when deciding and embarking on information sharing initiatives. By tailoring information sharing structures and governance mechanisms to the context of the transaction and the business relationship, companies may benefit from information sharing. Examples of benefits include reduced transaction costs, improved cooperation and secured external resources while avoiding unfavorable dependencies and opportunistic behavior.

In order to achieve these benefits, Figure 1 provides an outline for companies to formulate their own information sharing strategy. Such a strategy should answer several questions. First of all, it is critical to identify the current issues and opportunities in the supply chain. Information sharing in the supply chain requires at least two partners, sender and receiver of information. Therefore it is imperative to identify incentives for all involved partners. Incentives could be, for example, improved production planning, reduced overtime in production, shortened lead times, improved delivery precision and lowered inventory holding costs. Based on identified issues and opportunities, the next step for companies is to decide what information to share with whom, and how. Information sharing may need to be tailored for separate product flows, for example considering the product life cycle and structural complexity as well as competitive market environment. This differentiation could lead to that information sharing is expanded in some cases and eliminated in other cases with the purpose to avoid overflow of unnecessary information. As a final step, companies should be carefully select governance structures as a strategic response to the supply chain context.

Conclusions and future research

This paper sets out to conduct a systematic literature review with the aim of answering the following research question: What are the predominant theoretical perspectives to be integrated into a conceptual framework for classifying and evaluating cross-disciplinary empirical research on information sharing in supply chains? We have identified five pre-dominant theories that together represent eight out of ten (80%) of the identified instances. The five theories are TCE, RGT (e.g. social exchange theory and the relational view), CT, RDT and the (extended) RBV. We found that each of the theories has been used to investigate and understand several of the identified information sharing aspects including: reasons for sharing, what information to share with whom, how to share as well as pre-requisites, drivers and barriers to information sharing. The resulting framework is presented in Figure 1. The findings of the structured review and the proposed conceptual framework suggest a number of future avenues for empirical research and theory building. In the remaining part of this section, we would therefore like to draw attention to a number of important areas for future research.

First, future empirical research on information sharing in supply chains would benefit greatly from cross-fertilization and systematic comparison of established theories. Such cross-fertilization would enable the development of a holistic understanding of the rationale for information sharing (or lack thereof), structure and content, mechanisms employed as well as pre-requisites, barriers and drivers of information sharing in supply chains. We concur with Power and Singh's (2007) call for caution in cases where single theories are used to explain complex and connected supply chain relationships. In the words of Power and Singh (p., 1306): *"This mono-theoretic approach may be more conducive to studies focusing on dyadic perspectives. As a result, when trying to develop, test or verify theory outside of this narrower context, a multiple theory approach is perhaps more useful to explain the complex interplay of factors more likely to be found in the real world"*. We propose that the framework presented in this article provides specific suggestions on how this can be done. For instance, CT, TCE, RBV and RGT can all provide alternative explanations regarding the rationale behind information sharing in supply chains.

Second, as our results show that only a handful of empirical studies address the supply chain level, future research should expand its analytical unit beyond the dyad through appropriate theories that place more emphasis on information sharing in three-tier and extended supply chains (see also Klein and Rai, 2009). Certain theories such as social network analysis (Kilduff and Tsai, 2003) and stakeholder theory (Donaldson and Preston, 1995) hold promise in framing information sharing in supply chains in novel ways. For instance, social network analysis could be used to emphasize the role of inter-personal relationships and social ties in information sharing across multiple tiers in the supply chain (Borgatti and Li, 2009), whereas stakeholder theory could be used to understanding issues around sharing of investments/costs and benefits between supply chain partners engaging in information sharing (e.g. see Co and Barro, 2009). Although we agree that the noted empirical data collection issues can never be underestimated when moving beyond dyads (Klein and Rai, 2009), we propose that such challenges are worth taking up if the frontiers of supply chain information sharing research are to be expanded.

Third, future studies should employ CT in a more sophisticated way. As our systematic review suggests, CT has been useful for stressing the role of supply chain context in designing appropriate information sharing strategies. However, scholars employing CT appear to underplay performance measures as instruments to capture the outcome of information sharing, and they thus fail to "prove" any contingency factor in line with the requirements of the theory in its original form (see Donaldson, 2001). Rather, these studies seem to rely on perceptions of performance, typically captured through survey instruments (e.g. Stock *et al*., 2000; Yigitbasioglu, 2010). We submit that the explanatory power of CT can be significantly increased if future empirical studies seek to measure and compare performance *before* and *after* information sharing initiatives in supply chains. This change would allow drawing more sound conclusions regarding the influence of certain contingencies. In addition to surveys, in-depth case studies may be appropriate since researchers can gain access to accurate performance data (e.g. access to the case companies' information systems and/or performance records) from multiple, interconnected firms in the supply chain.

The paper has two key limitations. First, the developed framework is only based on the five pre-dominantly used theories. Other theoretical perspectives (from the 18 we identified in our review) could provide additional insights into information sharing in supply chains. Second, the study and the framework do not consider intra-organizational

information sharing. The framework could thus be complemented with the internal, cross-functional perspective of information sharing to capture any potential interactions between intra- and inter-organizational information sharing initiatives. Despite these limitations, we hope that this paper will inspire more systematic endeavors to conduct theory-driven empirical research (Melnyk and Handfield, 1998) and help advance our understanding of information sharing in supply chains.

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Appendix I

Table 7 - Categories and classification scheme used in extracting and analyzing data in the systematic review

Category	Description/Classification
Title	Complete title of paper
Author(s)	Complete names of authors
Journal	Journal in which the paper has been published
Year	Year of publication
Definitions	Definition of the term "information sharing"
Purpose	Brief outline of the purpose of the study
Findings	A summary of the key findings in the paper
Theoretical perspectives	A list of all theoretical lenses that are used to investigate and understand information sharing
Aspects of information sharing	Description of what specific aspects of information sharing was investigated in the paper
Unit of analysis	The part of the supply chain that was the focus of the research [Dyadic; Triadic; Extended]

Exploring information sharing in the extended supply chain: An interdependence perspective

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Purpose

To empirically explore demand-related information sharing in the extended supply chain.

Design/methodology/approach

Through a single, embedded case design, a range of methods are used to collect data from companies representing three different supply chain tiers, including focal company, first-tier suppliers and first-tier customers. The collected data is analysed through the theoretical lens of interdependence.

Findings

The findings indicate that the supply chain actors adapt information sharing to the pooled, serial or reciprocal type of interdependence. Information sharing is thus increased with key dyadic partners representing, for example, unique offerings and high market shares as percentage of total expenditure/sales. The study also unearths several barriers to information sharing beyond dyadic ties, including problems related to dis-aggregated, misinterpreted and/or incomplete information.

Research limitations/implications

The study empirically contributes to existing literature by exploring information sharing in the extended supply chain and by suggesting different approaches to information sharing depending on the type and intensity of interdependence between supply chain partners. Further, the paper contributes to existing literature on barriers of information sharing in supply chains by identifying barriers specific to multi-tier information sharing. 'Meta-information' (i.e. information about the shared information) is needed to overcome some of the barriers of sharing information in cases of weak, pooled interdependencies in the supply chain.

Managerial implications

Similar to previous empirical research, this exploratory study indicates that companies, in general, refrain from sharing information beyond dyadic ties. Supply chain managers would instead mostly focus on stronger, reciprocal interdependencies and emphasize dyadic information sharing. To further guide managers, a demand profiling framework considering market share and demand uncertainty is presented. It may be interesting to engage in multi-tier information sharing in particular cases where strong interdependence exists between three or more partners.

Originality/value

This study contributes to existing research on information sharing in supply chains by 1) empirically studying information sharing in an extended supply chain; 2) applying interdependence theory as its analytical framework; and 3) unearthing several barriers that are specific to multi-tier information sharing.

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Keywords: Supply chain management, information sharing, interdependence, networks, demand uncertainty, bullwhip effect

1. Introduction

The topic of inter-organizational information sharing has been on the agenda for decades drawing attention from both researchers and practitioners. Information sharing is, according to several authors, critical for improving the performance of supply chains (e.g. Forrester, 1958; Lee and Wang, 2000; Hult *et al.*, 2004). Suggested benefits range from relatively immediate and concrete aspects, such as improved forecasts and reduced inventory levels (Mason-Jones and Towill, 1997; Lee *et al.*, 2000; Taylor and Fearne, 2006), to more long term potential benefits, such as coordinated processes and enhanced planning in the supply chain (Mohr and Spekman, 1994; Sahin and Robinson, 2002).

Another group of researchers however raise a word of warning, suggesting that increased information sharing between supply chain partners may not always beneficial and is, in fact, limited in practice (c.f. Kemppainen and Vepsäläinen, 2003; Uzzi and Lancaster, 2003; Samaddar *et al.*, 2006; Roh *et al.*, 2008; Vanpoucke *et al.*, 2009). Kim *et al.* (2006, p. 316), for example, investigate a dyadic relationship in a supply chain and argue that: *"Forwarding raw downstream data upstream may result in distorted signals, data misinterpretation, and inaccurate assimilation. The consequences can be dire cumulatively across the whole supply chain."*

The mixed messages regarding benefits can partly be explained by conflating the reported and the actually studied units of analysis. Results and implications are often reported on the supply chain level (Kembro and Näslund, 2014) whereas the main body of information sharing literature investigates dyadic buyer-supplier relationships (Choi and Liker, 2002; Li *et al.*, 2005; Taylor and Fearne, 2006; Caridi *et al.*, 2014). An implication of the predominant focus on dyads is that researchers have a limited view and understanding of information sharing across supply chains. In order to bridge this gap, several authors recommend further empirical research exploring information sharing beyond dyadic relationships and into the extended supply chain (Choi and Liker, 2002; Meixell and Gargeya, 2005; Giunipero *et al.*, 2008; Bastl *et al.*, 2012).

Moving beyond the dyadic relationships is particularly interesting considering that supply chains can be construed as networks of relationships among organizations engaged in production and distribution activities to satisfy end customer requirements (Christopher, 1998; Stevenson and Spring, 2009). The network metaphor is often used to convey multi-directional links and interdependent activities and exchanges among multiple tiers in the supply chain (Harland, 1996; Lamming *et al.*, 2000; Manuj and Sahin, 2011). In a supply chain, suppliers can offer their products and services to multiple customers and can also form indirect links with other suppliers and business partners (Saunders, 1997; Lamming *et al.* 2000). The network view of supply chain operations (Hayes, 2008) can thus help to explain the existence of interdependencies (Dubois *et al.* 2004) among different dyads or chains and the difficulties inherent in sharing information across multiple supply chain tiers.

Despite the above, there is scant empirical evidence on information sharing in the extended supply chain (Kim *et al.*, 2006; Kembro and Näslund, 2014). The aim of this paper is to empirically explore information sharing across multiple supply chain tiers, and its potential barriers. More specifically, we draw on a case study of demand-related information sharing (henceforth referred to as information sharing) in the supply chain of The Absolut Company (TAC). The focus of the study is on one product, namely the 70 cl bottle of Absolut Citron, in the focal company's portfolio for which the supply chain partners have worked for three decades with increasing information sharing with certain partners in order to reduce inventory levels. Despite the partners' efforts, there are still concerns about unsatisfactorily high inventory levels. In order to reduce inventory levels further, it may be necessary to move beyond the dyadic ties and share information across multiple tiers. However, moving beyond dyadic relationships entails overcoming several barriers in relation to

increasing information sharing. Drawing primarily on Thompson's (1967) types of interdependence, we seek to explore and understand what information is currently shared between the supply chain members and understand the key barriers to sharing information across multiple supply chain tiers.

The paper contributes to the literature on information sharing in supply chains in by empirically demonstrating how reciprocal and serial interdependence influence information sharing patterns in dyads, as well as how pooled interdependencies in the extended supply chain create difficulties of sharing information across multiple tiers. The study suggests that information sharing intensity in dyads needs to be adapted depending on the type of interdependence (reciprocal or serial). Furthermore, our empirical study unearths three barriers that are specific to information sharing among multiple supply chain tiers that exhibit pooled interdependencies: a) demand information disaggregation, b) risk of demand information misinterpretation, and c) risk of making production and distribution decisions based on incomplete information. The study presents also practical implications for managing information sharing in accordance with the type and intensity of interdependencies in the extended supply chain.

The rest of the paper is structured as follows: the next section introduces related literature on information sharing and outlines the analytical framework of the study. Thereafter, the case supply chain is presented including justification of the single, embedded case design and details of data collection and analysis. Next, the findings are presented in terms of the current dyadic information flows and the identified barriers of sharing information across the extended supply chain, followed by a discussion of these findings. The paper concludes by drawing out research and managerial implications as well as pointing out limitations and future research opportunities.

2. Literature review

2.1 Benefits of information sharing in supply chains

Related to industrial dynamics, the *Beer Distribution Game* illustrates the amplification of demand variability as orders move up the supply chain. This phenomenon, which is commonly known as the "bullwhip effect", increases uncertainty in the order fulfilment processes (Forrester, 1958; Sterman, 1989). Upstream partners are unable to forecast demand accurately and, as a result, make non-optimal supply and production decisions. Ultimately, the efficiency for all supply chain partners decreases when companies allocate sub-optimum capacities and carry excessive inventory levels (Lee and Whang, 2000).

To address this issue and reduce demand uncertainty, several authors argue that sharing information across several supply chain tiers could result in well informed business decisions for the members of the extended supply chain (e.g. Van Ackere *et al.*, 1993; Greis and Kasarda, 1997; Chen *et al.*, 2000; Sahin and Robinson 2002; Ketzenberg *et al.*, 2007; Yu *et al.*, 2010). Information sharing can occur at three organizational levels. On the operational level, companies share order information (Klein and Rai, 2009) and demand or sales data (Patnayakuni *et al.*, 2006) to facilitate orders and reduce information distortion and stock levels (Yu *et al.*, 2010). On the tactical level, companies share quarterly forecasts (Bowersox *et al.*, 2000), plans and trends (Yigitbasioglu, 2010; Ramanathan, 2012). Thereby it is possible to facilitate resource planning and allocate appropriate capacities in order to reduce inventory levels and improve reliability of shipments to downstream partners. Related benefits include lower operating costs, higher productivity and improved planning of production for all supply chain partners (Bowersox *et al.*, 2000; Patnayakuni *et al.*, 2006; Klein and Rai, 2009). Finally, on the strategic level, companies share one-year forecasts, sales promotion and marketing strategies (Mentzer *et al.*, 2001) in order to enable effective planning of future purchases and growth within the alliance (Mohr and Spekman, 1994).

2.2 Barriers to dyadic information sharing in supply chains

Implementing and benefiting from information sharing in supply chains may, however, be rather difficult. Researchers have identified several barriers to increasing information sharing in supply chains, although their analytical focus is on the buyer-supplier dyad. One issue is the lack of information quality which can be determined by accuracy, timeliness, credibility and proper formatting of the information. Without reliability or validity, information has no value for the receiving partner (Monczka *et al.*, 1998; Lee and Whang, 2000; Moberg *et al.*, 2002; Li *et al.*, 2006). A second issue relates to the linking of inter-organizational exchange processes and IT-systems. Not all members in the supply chain are connected and have the capability to exchange data from, for example, an ERP system. The process of implementing new systems can be negatively perceived due to high capital investments and lack of cost sharing agreements (Christopher and Jüttner, 2000; Lee and Whang, 2000; Moberg *et al.*, 2002; Shore and Venkatachalam, 2003; Patnayakuni *et al.*, 2006; Fawcett *et al.*, 2007). Lee and Whang (2000) also point out the issue of sharing benefits among supply chain partners. There is a risk that only one partner reaps the benefits created by increased information sharing.

Another barrier is the handling of confidential information and lack of trust. Supply chain members are often reluctant to share information because of fear of opportunistic behavior, i.e. partners exploiting information for self-interest. Companies may therefore refrain from sharing information unless prevention of leakage to competitors is guaranteed. In a similar vein, there is a risk that shared information may negatively affect the competitive position of the buyer or supplier in relation to their competitors. This issue could negatively impact on firms' commitment to relationships and their willingness to share information with supply chain partners without concern that this might be misused (Moorman *et al.*, 1992; Cooper *et al.*, 1997; Seidmann and Sundararajan, 1998; Spekman *et al.*, 1998; Christopher and Jüttner, 2000; Lee and Whang, 2000; Moberg *et al.*, 2002; Shore and Venkatachalam, 2003; Patnayakuni *et al.*, 2006; Fawcett *et al.*, 2007; Klein and Rai, 2009). A final barrier, related to power-dependence theory (Emerson, 1962), is power asymmetry which may create resistance to sharing information. A company may fear that they could become overly dependent or the dominant player does not wish to lose the current favorable position and bargaining power in a supplier-buyer relationship (Seidmann and Sundararajan, 1998; Christopher and Jüttner, 2000). Indeed, the relative power of buyers/suppliers to one another can influence the degree of (inter)dependencies in supply chains considering whether market shares as percentage of total expenditure/sales are high or low, and also how buyers and suppliers are connected to each other and to the broader supply networks (Cox, 2004; Danese *et al.*, 2004).

2.3 Connected relationships and interdependencies in supply chains

Supply chains can be regarded as networks of multiple, interdependent actors and their respective constellations of activities and resources (Harland, 1996; Lamming *et al.*, 2000; Håkansson and Snehota, 2002; Ford *et al.*, 2003). The notion of connectedness, originating in social exchange theory (see Cook and Emerson, 1984), helps to explain the transition from buyer-supplier dyads to networks of relationships (Easton, 1992). In particular, it suggests that a dyadic business relationship (e.g. between actors A and B) might be connected to another relationship (e.g. between actors B and C). The nature and substance of the dyadic relationship between A and B (e.g. in terms of resource investments or information dependencies) may well influence, or be influenced, by the nature and substance of the dyadic relationship between B and C (Easton, 1992). Related, all relationships have indirect effects on other business relations within the broader network and, therefore, all firms, as well as their respective productive activities and resources, interrelate to one another, at least to some extent (Anderson *et al.*, 1994; Gadde, 2014).

Connectedness of inter-firm relations implies a certain type and intensity of interdependence among supply chain actors (c.f. Gomes and Dahab, 2010). Originating in organization theory and notably the work of Thompson (1967), interdependence theory suggests that groups or units within an organization are interdependent due to their technological requirements. Thompson (1967) identified three main types of interdependence: a) Pooled interdependence signifies two activities without direct links that share a common resource and together contribute to a system output: *"each part renders a discrete contribution to the whole and each is supported by the whole"* (Thompson, 1967, p. 54); b) Serial interdependence exists through direct links between activities where the input of one part is directly dependent on output from another; and c) Reciprocal interdependencies represent mutual exchange of inputs and outputs with *"each unit posing contingency for the other"* (Thompson, 1967 p. 55). The type of interdependence presents implications for intra-organizational communication and coordination – as we move from pooled to serial to reciprocal interdependencies between units, communication requirements and coordination costs increase (Thompson, 1967).

Interdependence theory has been extended in the study of inter-organizational exchange relationships (Skipper *et al.*, 2008) and, particularly, the combination of serial, pooled and reciprocal interdependencies (Thompson, 1967) can be useful to understand the mechanics of supply chains as networks of exchange relationships (Harland, 1996). According to Dubois *et al.* (2004, p. 6), *"[t]he supply chain concept relies strongly on the notion that there is sequential interdependence among activities which, therefore, need co-ordination"* with focus on adjusting and aligning such activities in order to increase output, reduce costs or increase the service level of the system. In addition, pooled interdependencies manifest themselves in supply chains in that any organization represents a range of resources and activities that need to be efficiently integrated, despite the fact that this organization may be a member of several different supply chains. In other words, many supply chains compete for the same resource where each company can have different focus and role in the different supply chains (Lamming *et al.*, 2000). In a similar vein, Dubois *et al.* (2004, p.6-7) elaborate on reciprocal interdependence in supply chains: *"where ex ante matching of plans is required, firms need to interact in order to make the plans fit into their different production contexts. This interaction may also include adjustments of resources used in, or refined by, the activities subject to co-ordination to improve resource utilisation or the means by which the activities are co-ordinated."*

Despite the above, it appears that the potential of interdependence theory for empirically studying inter-organizational information sharing in supply chains has been underplayed (Kembro *et al.*, 2014). We submit that considering the different types and intensities of interdependence among supply chains can help understand better not only potential barriers to information sharing in the extended supply chain, but also how such information sharing may need to be adapted to the particular context. According to Danese *et al.* (2004), for example, the particular characteristics of interdependence between firms (whether dependencies are mutual or 'one-way') and the number of interacting firms are important to consider when selecting coordination mechanisms. Cox (2004) frames interdependence in the context of high buyer power relative to supplier, and vice versa. In other words, interdependence exists when both buyers and supplier can exert power to each other. Characteristics indicating the intensity of interdependence (i.e. either weak or strong) include the number of potential buyers and suppliers; percentage share of total market for supplier; switching costs and; uniqueness in offerings (ibid).

3. Methodology

A single-case, embedded design (Yin, 2014) was adopted to explore information sharing and related barriers across multiple supply chain tiers. The embedded cases refer to the interconnected dyadic relationships in the studied supply chain (e.g. first-tier supplier and TAC; TAC and first-tier customer).

Information sharing across supply chains encompasses several organizations as well as multiple individuals working within different firms. According to Cassell and Symon (2004, p. 323):

"the phenomenon is not isolated from its context … but is of interest precisely because the aim is to understand how behaviour and/or processes are influenced by, and influence context."

The case study research strategy was thus selected to capture important contextual information regarding the supply chain studied, and offer insights into contemporary events with minimal control of the observed behaviours (Eisenhardt, 1989; Ellram, 1996; Yin, 2014).

Also, the case study research approach provides depth of understanding of the phenomenon under study (i.e. information sharing and related barriers) since it enables collecting rich data from multiple firms (e.g. Easton, 2010) within the supply chain in focus (here first-tier suppliers and customers in addition to the focal company), and thus capturing their multiple perspectives and views on barriers of information sharing. Data collection and analysis beyond the dyadic level, which was enabled by the case study approach, helped understand the interconnections and interdependence between firms and the barriers to information exchanges across the supply chain.

3.1 Case selection

The case selection was guided by the research purpose to explore demand-related information sharing among supply chain actors including the focal company, suppliers, suppliers' suppliers, customers and customers' customers. The unit of analysis is therefore defined as *"the demand-related information shared between actors in a supply chain in relation to the physical flow of a certain product"*. Although no data were collected directly from second-tier partners, interviews with first-tier suppliers and first-tier customers provided insights into second-tier partners' operations and their relations with the first-tier suppliers and customers.

The single-case, embedded design was deemed appropriate since the selected case is conceived as critical one (Yin, 2014) in that the supply chain focal company, The Absolut Company (TAC), has worked systematically for nearly three decades to develop information sharing with their supply chain partners. TAC has a long-established and tailored approach to sharing different information with different partners. Hence, the selection builds on critical case sampling (Yin, 2014). As Patton (2002, p. 236) puts it:

"critical cases are those that can make a point quite dramatically or are, for some reason, particularly important in the scheme of things".

Given the long and systematic work to improve information sharing in the supply chain, it could also be argued that *"if it doesn't happen there, it won't happen anywhere"* as well as *"if that group is having problems then we can be sure all the groups are having problems"* (ibid). The embedded design enabled studying information sharing in specific, interconnected customer-supplier dyads (e.g. TAC and first-tier suppliers; TAC and first-tier customers), as well as exploring barriers of information sharing across the supply chain in focus.

This study applies stratified sampling by including six component suppliers and two purposefully selected markets (see Figure 1). According to Patton (2002, p. 240), stratified samples can be described as samples within samples with the purpose to:

"capture major variations rather than to identify a common core, although the latter may also emerge in the analysis."

The two markets were selected illustrating both a "common" and an "extreme" market situation in TAC's portfolio. The common market is represented by the UK market which includes one market company supplying a number of wholesalers who in turn distribute the product through an extensive

network of retailers. The distribution network is characterized by *ad-hoc* promotional activities and campaigns which increases uncertainty in the demand pattern. The extreme market is represented by the Swedish market which signifies a unique setting with a monopolistic market situation. There is only one major customer on the market and promotional activities and campaigns are restricted by law. By including these divers markets, the aim was to explore if information sharing and related barriers differ between the two contexts.

Before investigating the information flows, all material flows between supply chain partners were mapped, see Figure 1. Upstream, the second-tier suppliers are represented by process industries characterized by large, constant production quantities. These industries are owned by global enterprises and supply raw materials including aluminium, plastic, glass and paper to the first-tier suppliers. The first-tier suppliers use the raw materials to produce and provide a range of components to the bottling facility in Åhus Sweden for production and packing of 70 cl bottles of Absolut Citron. The purchased components include flavour, bottle, label, closure, cap and shipper whereas water is retrieved from TAC's own wells. Most of the first-tier suppliers are part of global enterprises serving multiple markets. In the downstream supply chain, which is characterized by numerous distribution chains, the first-tier customers are represented by market companies owned by Pernod Ricard. The Pernod Ricard group, which holds one of the most prestigious portfolios of different brands in the sector, acquired TAC in 2008. Since then, TAC and the market companies have the same owner but are separate companies with clearly divided responsibilities.

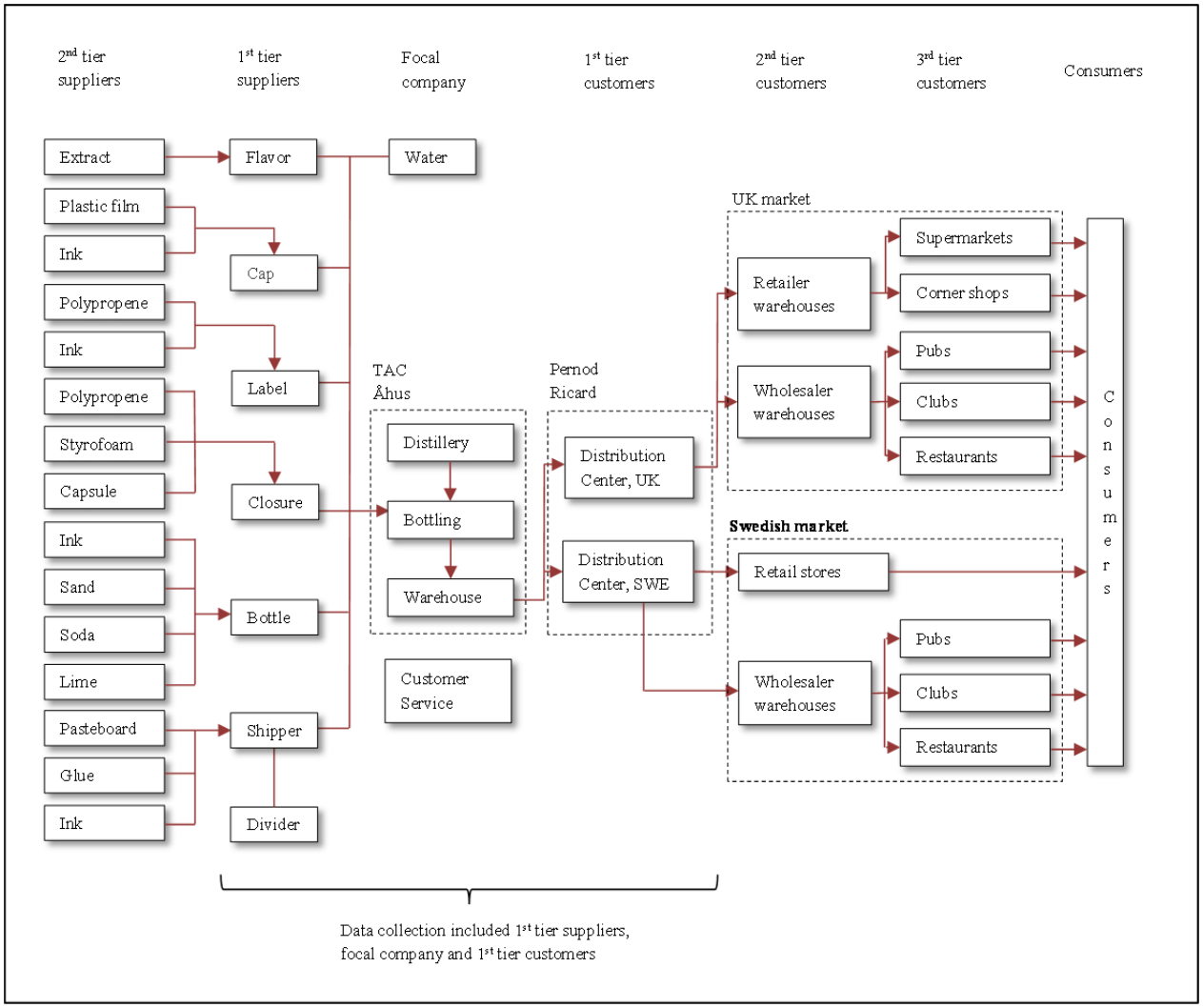

Figure 1 – The Absolut Citron supply chain including UK and Swedish market: actors and material flows.

3.2 Data collection

The case study was conducted in collaboration with TAC during a period of five months. Initially, a reference group was formed consisting of the Director Supply Chain Management and Chief Procurement from TAC as well as two senior researchers. The reference group supported the study, for example by identifying representative component suppliers and market companies and providing feedback on the interview guide included in the study. A range of methods was used to collect data from actors representing three tiers of the described supply chain: first-tier suppliers, focal company, as well as first-tier customers represented by Pernod Ricard market companies, see Table 1.

Table 1 – Overview of selected companies and interviewees.

Tier	Product	Company	Country	Years as TAC partner	Staff	Turnover	Interviewees (number of interviews given in brackets)
1st tier customer (distributor)	Absolut Citron	Pernod Ricard SWE	Sweden	5	18,777 (total Pernod Ricard)	70 billion SEK (total Pernod Ricard) [1]	Supply Chain Manager (1)
1st tier customer (distributor)	Absolut Citron	Pernod Ricard UK	UK				Operations Director (1)
Focal company (customer service)	Absolut Citron	TAC	Sweden		680+ (total The Absolut Company)	11.4 million 9-liter cases of Absolut Vodka (all articles)[2]	Regional Manager Sweden, Regional Manager UK (1)
Focal company (production)	Absolut Citron	TAC	Sweden				Director Operations (1), Director Supply Chain Management (1), Chief Procurement (1), Production Manager (1), Quality Engineer (1)
1st tier supplier	Glass bottle	BM[3]	Sweden	>25	500	1 billion SEK	Sales Manager, Supply Chain Manager, Order administrator (1)
1st tier supplier	Closure	CS	Sweden	10	55	100 million SEK	Managing Director (1)
1st tier supplier	Label	LS	Sweden	10	87	180 million SEK	Key Account Manager, Chief Procurement (1)
1st tier supplier	Packaging (Shipper + divider)	PM	Sweden	>25	1400	4.8 billion SEK	Key Account Manager (1)
1st tier supplier	Cap (Sleeve)	CM	UK	10	1000	1.2 billion SEK	Sales Manager (1)
1st tier supplier	Flavour	FS	Sweden	>25	50	80 million SEK	Key Account Manager (1)
Total							**14 interviews**

[1], [2] Because of confidentiality, turnover of Pernod Ricard is listed as a total instead of each market separately. For the same reason turnover for The Absolut Company, as per the annual report, is listed in millions of 9-liter cases.

[3] Because of confidentiality, the real company names have been replaced with fictional names.

Data collection started with a full-day visit to the focal company's site. The day included five one-hour semi-structured interviews with key staff, company presentations and, finally, a chance to review documents related to information sharing processes, performance improvements and past and current initiatives. In the next step, TAC enabled access to first-tier suppliers and first-tier customers. TAC and the respective supply chain partners recommended staff with insights to material flows and related information flows. These personnel were contacted first by email and thereafter by telephone. Certain companies chose to include more than one person for the interview. To ensure that the interviewees understood and could answer the questions, an introduction of the research project together with the interview guide were sent to each interviewee beforehand.

In total, 14 semi-structured interviews were conducted: five with TAC, Åhus; one with TAC Customer Service, Stockholm; six with TAC's first-tier suppliers and two with TAC's first-tier customers. Each interview lasted for approximately one hour. Details on the interview guide are provided in the Appendix. To increase the truth-value of the study, which *"necessitates congruency of the information provided by informants and the researcher's interpretation thereof"* (Da Mota Pedrosa *et al.*, 2012, p. 279), two additional steps were taken. First, the transcriptions and the summary of each interview were sent back to the respective company. The interviewees were then given ample time to review and amend the documents. Second, after confirming the summaries with all interviewees, a half-day workshop was conducted involving two researchers and the Director Supply Chain Management and Chief Procurement from TAC. During the workshop, the findings of the study were discussed and reflected upon.

3.3 Data analysis

The data analysis process followed the ladder of analytical abstraction (Carney, 1990; Miles and Huberman, 1994). With the aim of exploring and understanding information sharing and related barriers, the first step in the analysis was to code the collected data. A provisional start list of coding categories was created prior to data collection. These categories were identified from the literature on information sharing in supply chains. Examples of coding categories included: unit of analysis (e.g. dyadic upstream or downstream vs. the extended supply chain), organizational level (strategic, tactical, and operational) and barriers of dyadic information sharing (e.g. lack of trust, and lack of information quality).

Considering, however, that research on information sharing has mainly focused on dyadic relationships there may be other relevant coding categories on a supply chain level. Therefore, this study also applied 'open coding'. Open coding represents "*methods used to break down case study data in order to analyse, conceptualize, and develop categories for the data"* (Ellram, 1996, p. 108). One example of a category that was developed during the data analysis includes the barriers related to dis-aggregated, misinterpreted and/or incomplete information. Eventually, a complete set of coding categories was developed which enabled a *"logical link between the data and the results"* (Näslund *et al.*, 2010, p. 337).

The second step involved identification of trends and themes in the collected data. This step is often referred to as pattern coding (Miles and Huberman, 1994) or axial coding (Ellram, 1996). By writing up memos with pattern codes after each interview round, it was possible to *"look for recurring phrases or common threads in informants' accounts"* (Miles and Huberman, 1994, p. 70). An example of such a common thread was the interviewees' perception of difficulty related to making use of information shared beyond the dyadic relationships. As common threads emerged from a sub-sample of the entire dataset, they were compared with the rest of the already transcribed interviews. Also, insights from conducted interviews were brought up in the remaining interviews to receive additional comments in order to confirm or contest a common thread. The data analysis

process can thus be described as an iterative one where *"the analysis begins simultaneously with the gathering of the data, and continues throughout the data collection process and beyond"* (Ellram, 1996, p. 108).

In the final stage of the analysis process, the findings were discussed, confirmed and reflected upon with key interviewees in the focal company of the studied supply chain. To confirm the conclusions of the study and ensure validity, a final presentation was carried out at the organization's site. Project reviews of this type are important to substantiate the findings and *"joint reflections of the individuals in the system studied and the researcher will enhance the understanding and also take the learning forward – for both the researcher and the organization"* (Näslund *et al.*, 2010, p. 337).

4. Findings

The exploratory case study findings indicate that there is no information sharing across three or more tiers in the studied supply chain. In other words, no information was found to be shared across 1) second-tier customer and focal company; 2) first-tier customer and first-tier supplier; 3) focal company and second-tier suppliers; or 4) first-tier customers and third-tier customers. Instead, all current information flows appear to be dyadic. Below, the current information flows are presented followed by an outline of barriers to information sharing beyond dyadic relationships.

4.1 Current information flows in dyadic supply chain relationships

The information shared between dyadic partners appears to vary depending on characteristics that determine the type and intensity of interdependence. Such characteristics include, for example, percentage of total volume and value procured per component and number of potential buyers and suppliers and related switching costs.

On the operational level information sharing primarily supports the daily flow of products. Certain information, such as placing and confirming orders, delivery and production schedule, is shared between all dyadic relations throughout the supply chain (e.g. between first- and second-tier suppliers and between TAC and respective market company). TAC adapts shared information with first-tier suppliers based on the volume procured of each component. With CM, for instance, the caps represent a relatively low volume of the product portfolio. Therefore order information is only shared four or five times per year. In comparison, for labels and capsules, the interdependence between TAC and their suppliers is stronger; the total volume is relatively large and, in addition, each component is unique for respective market such as UK and Sweden. In response, order information is exchanged on a weekly basis. For two other components, the glass bottle and packaging, the volumes are so large that TAC decided to implement a Just-in-Time (JIT) system with their suppliers (BM and PM). This logistics system includes three deliveries each day from the suppliers' sites to Åhus. To support this arrangement, the partners have implemented an IT system which enables quick and secure data transition multiple times per day. Should this IT system fail, TAC's production facility, which is a bottle neck in the supply chain, could risk of standing idle. Such a scenario would have devastating impact on the performance of the entire supply chain.

On the tactical level, information sharing is on purpose limited throughout the supply chain. In comparison with long- and short-term, it appears, according to TAC, that mid-term demand is the most volatile and unpredictable. As a result, related information flowing upstream in the supply chain lacks in precision which hampers planning and managing the ongoing operation. Eventually, as noted by TAC and BM, wrong products and quantities are produced and delivered leading to unnecessarily high inventory levels and tied up capital throughout the supply chain. Similarly, LS and CS note that the lack of precision in mid-term forecasts often lead to confusion between supply chain partners. They express concern with the fact that forecasts inherit assumptions and interpretations

made by staff in downstream firms. Therefore, the interviewees preferably refrain from sharing this type of information. In only one case, together with BM, TAC has chosen to emphasize information sharing on the tactical level. BM is a close partner, representing a large percentage of TAC's turnover. BM has also tailored some of their production facilities for TAC's components. Hence, the two partners seem to be reciprocally interdependent and update each other on quality concerns and changes in design every third month to facilitate planning of design and production as well as scheduling labour and assigning capacity in etching and coating facilities. For other partners representing strong serial interdependence, information sharing is intensified at the operational level. As an example, the emphasis on operational information sharing including daily order updates has allowed PM to increase flexibility to adjust production according to daily changes in demand.

In the downstream supply chain, Pernod Ricard UK arranges monthly meetings with major clients to discuss promotional activities and upcoming demand in terms of volume for the coming three months. Despite this effort, demand uncertainty is high due to unforeseen promotional activities and the upstream partners including TAC and their suppliers have difficulties to properly plan production to match supply and demand. In comparison, Pernod Ricard Sweden does not share any information on the tactical level, partly because of regulations related to marketing and promotional activities but also due to low demand uncertainty. The demand of the Swedish market is sufficiently predictable for upstream partners to create and rely on internal forecasts based on historical data.

Finally, on the strategic level, TAC informs all suppliers about one-year forecasts and changes in the product portfolio and design. Certain products such as bottles, capsule and packaging material are sourced from single companies signifying reciprocal interdependence between the partners. With these companies, TAC shares additional information on planned future growth and changes in production techniques and/or facilities. In the case of bottles, BM has tailored its production facilities for TAC. It is a lengthy process to increase the production capacity and therefore TAC and BM set up five year plans concerning planned expansion and required investments. The purpose of selective information sharing is multi-faceted. TAC improves their relations with key suppliers while acquiring an insight to each other's processes. Thereby it is possible to lower operating costs. The partners also create a shared view of the future to predict future growth and secure sufficient production capacity.

The findings of the study indicate that first- and second-tier suppliers share similar information on the strategic level as TAC and its first-tier suppliers. As an example, CS liaises with their main suppliers to discuss long-term forecasts and intentions to phase out or introduce new products. Downstream, between the Pernod Ricard market companies and its customers, information sharing is limited on the strategic level. Primarily, in the UK market, information sharing relates to marketing strategies and one-year forecasts with key customers. The details of existing dyadic information sharing and related benefits are summarized in Table 2.

Table 2 – Details of existing dyadic information sharing and perceived benefits.

Organizational level	Companies involved		What information is shared	Benefits of information sharing
Operational level	All dyadic relationships in the supply chain		Order information (each order is placed, acknowledged with confirmed delivery times) and changes in production and delivery schedule (intervals change between suppliers depending on volume ordered).	Supporting the daily physical flow of products through the supply chain.
	TAC	BM, PM	Order for the upcoming 7 days (weekly) specifying product details including quantity, # pallets, day and time. Twice per day, five days per week partners follow up on the production plan and dispatched goods.	Optimized utilization of assigned capacity.
Tactical level	TAC	All suppliers	Forecast indicating what will be produced the coming four to twelve weeks (intervals change between suppliers depending on volume ordered).	Attempt to predict and match supply with demand in distribution to better synchronize production and logistics capacities.
	TAC	BM	Changes in bottle design (quarterly); detailed information on products and quantities required for the coming three months.	Improved planning of production, reserved capacity and scheduling of labour.
	Pernod Ricard UK	2nd tier customers : major clients	Monthly meetings to discuss promotional activities and upcoming demand in terms of volume for the coming three months (this information is passed on by Pernod Ricard upstream to TAC).	Improved production plans resulting in reduced inventory levels, reduced tied up capital and a mitigated risk of depleted products.
Strategic level	TAC	All suppliers	One-year demand forecast and upcoming design changes; phasing in and out of different products; planned changes in material or supplier base.	Strengthened relationship and increased trust between partners.
	TAC	BM, PM, CS	Additional information on planned future growth and changes in production techniques and/or facilities.	Shared view of the future and potential growth to ensure that sufficient production capacity is available.
	TAC	BM	Five-year plans concerning planned expansion and required investments.	Minimized risk of facing a stock-out in any market.
	2nd tier suppliers	1st tier suppliers (e.g. CS)	Product life cycles; introduction or phase-out of certain product segments; material-availability from each supplier to plan ahead and avoid any shortfalls of raw material or components.	Increased productivity by minimizing risk of break-downs.
	Pernod Ricard UK	2nd tier customers : major clients	One-year joint business plan including details on brands, sizes, quantities, new product introductions and upcoming promotional activities (this information is passed on upstream to TAC)	Shared view of the future and potential growth to ensure that sufficient production capacity is available.

4.2 Barriers to information sharing beyond dyadic supply chain relationships

The findings of the study suggest three barriers to information sharing across multiple supply chain tiers. The first barrier relates to dis-aggregation of demand information. TAC does not see the value of passing on information from downstream partners for single products and markets because separately they represent a relatively small volume for their upstream partners. Such relationships thus entail weak interdependence. The following quote from the interview with the Director Supply Chain Management, TAC, underlines this barrier:

"We never sent that piece of information directly on upstream in the chain because it represented a relatively small flow of products."

All first-tier suppliers follow a similar reasoning when deciding not to directly send information from TAC to their upstream partners, the second-tier suppliers. As an example, CS never forwards any information directly from TAC to their suppliers. Instead, CS aggregates all orders from TAC before sending orders upstream. CA also produces forecasts per material before sharing with their suppliers of aluminium capsules and microcellular plastic (Managing Director, CS). A second example is provided by BM. They use same raw material to produce glass bottles for several customers including TAC. Rather than sending just TAC's demand, BM aggregates all demand-related information and creates a yearly forecast and orders which are then submitted to respective raw material suppliers (Supply Chain Manager, BM).

To address the barrier of demand dis-aggregation and increase the volume share, one alternative would be to aggregate demand information for certain products and markets so that the combined volumes would be significant for upstream partners. However, most components used for the final product are customized already at the first-tier suppliers' site. Not only are the products sold in a wide range of different sizes, but also the components have unique printing and coating for respective market implying that it is not possible to swap components for the Swedish market and send it to the UK, and vice versa (Director Supply Chain Management, TAC).

The second barrier is the risk of demand-information misinterpretation by supply chain partners. The Director Operations, TAC, elaborates:

"To be able to use information, I believe that one must understand where it comes from. You have to understand what the information really means and I am not sure that is always the case."

There is an issue with using a common terminology to interpret the demand information for different products that are supplied throughout the chain. It is not given that a product, considering both stock-keeping unit and bill-of-material, translates exactly the same in each node in the supply chain. For example, one "piece" of Absolut Citron could actually mean one bottle, one carton of several bottles or a whole pallet. This information must then also be translated into the various components for first-tier suppliers to understand. The risk of misinterpretation is therefore apparent and may require additional information to help interpret or complement the shared information with the aim of exploiting pooled interdependencies. In addition, there is an issue with the potential misinterpretation of a range of factors that impact future demand. TAC and most of their first-tier suppliers would be interested in receiving Point-of-Sales (PoS) data from their downstream supply chain partners to optimize the utilization of their production capacity. However, signifying a reciprocal type of interdependence, TAC depends on the respective market company to avoid misinterpretations of future demand in order for them to be able to create accurate production plans and supply products on-time in-full (OTIF). This issue is emphasized by the Director Supply Chain Management, TAC:

"If we received Point-of-Sales data directly without any interpretation, we would probably have drawn the wrong conclusions."

In the UK market, for instance, factors that are important to consider include future campaigns for Absolut Citron and other brands in the portfolio as well as competitors' campaigns. With this barrier in mind, TAC plans to emphasize this type of intensified dyadic information sharing with the major market companies in terms of volume and value instead of engaging in information sharing beyond the dyadic relationships. For less extensive markets, it could be possible to receive and produce based on PoS data. According to TAC, the sharing of PoS data across three tiers would have worked in the relatively stable Swedish market if Systembolaget[4] was the only retailer. The barrier arises, according to the Director Supply Chain Management, TAC, when dealing with the heterogeneous market represented by different customers and different ordering patterns:

"Yes, it would have worked if it was only Systembolaget. The problem is that we have all the other customers. Then the value of the specific information is diminishing."

In fact, TAC had previously based production decisions on PoS data from Systembolaget. The PoS data represented one product, the Absolut Original 35 cl bottle, which, at the time, signified low demand uncertainty due to the fact it was only sold on the Swedish market. The PoS data was received through The Pipechain® software[5], which had been implemented at the first-tier customer's warehouse site. This arrangement resulted in lower inventories both at TAC's and the customer's site. At that time the customer only held one day of inventory in their warehouse.

The third barrier relates to the risk of making production and distribution decisions based on incomplete information about, for example, logistics requirements and restrictions. As the Director Supply Chain Management, TAC, explained:

"If we were to skip Pernod Ricard UK and instead connect directly with Tesco or a similar customer, we would have no clue. Perhaps there is a specific detail that must be attached to the bottle before it is sent to them for this specific campaign which requires an extra three week lead time. Or perhaps there are restrictions how much can be stored at a certain time at a 3PL warehouse. There are many pieces of the puzzle that are missing."

In response to the incomplete information, upstream partners therefore rely on the UK market company to filter the PoS and provide TAC with monthly updates of future demand. Pernod Ricard UK is in a better position to understand emerging trends while also considering the logistics arrangements and constraints at the receiving end (Operations Director, Pernod Ricard UK; Director Supply Chain Management, TAC).

Similarly, in order to ensure that all customer orders are taken care of and that inventory levels are kept as low as possible, TAC puts great effort on planning and scheduling production. Each day and hour of the year, TAC meticulously plans what will and how much will be produced for each production line. These arrangements put specific constraints on exactly what needs to be supplied and produced, and when. If TAC's first-tier suppliers would receive PoS data and forecasts from the second- or third-tier customers without guidance from TAC, it would be impossible to translate the data into actual production and shipment details (Supply Chain Manager, BM; Key Account Manager, PM). Particularly BM and PM who have implemented a Just-In-Time system with TAC must receive TAC's input to the logistics puzzle. The Chief Procurement, TAC, adds:

"There is so much information that is missing. Then BM would not get the piece of the puzzle how we think about scheduling production in relation to increasing or decreasing stock. They have no clue about what we plan to run in production. That piece of information must be considered."

[4] Systembolaget is a government owned chain of retail stores selling liquor in Sweden.
[5] The Pipechain® software is a commercial software for managing the flow of products in a supply chain.

5. Discussion of findings

This section discusses the above-presented findings regarding dyadic information sharing and barriers to information sharing in the extended supply chain (i.e. beyond the dyad) by drawing on the notion of connectedness of relationships (e.g. Easton, 1992) and Thompson's (1967) types of interdependence.

5.1 Current information flows in dyadic supply chain relationships

Information is currently shared between directly connected, dyadic partners. The direct connection seems to play an important role for creating a common understanding between the involved partners. This understanding builds on several factors including: regular face-to-face meetings which improve relationships and build trust; contracts detailing what type of information to share and when; common terminology for interpretation and understanding of shared information. Particularly, in the case when problems arise, personal relations and contracts seem important for the partners to jointly resolve any issues and together learn how to improve in the future.

The direct connection in dyadic supply chain relationships studied indicates either reciprocal or serial interdependence (Thompson, 1967; Dubois *et al.* 2004). Based on the factors presented by Cox (2004) and considering the definition by Dubois *et al.* (2004), it appears that two supplier relationships exhibit characteristics of strong, reciprocal interdependence. Both TAC's suppliers, BM and PM, represent high volumes of uniquely designed components. One of the suppliers even tailored some of their production facilities for TAC. Due to the reciprocal type of interdependence, the partners have intensified information sharing on the strategic level in order to develop business processes as well as to create a shared view of the future and secure capacity for up to five years. The partners also implemented an advanced JIT system and mutually adapted their processes and IT systems to support the material flow on the operational level and optimize utilization of assigned capacity.

Referring to Dubois *et al.* (2004), serial (or sequential) type of interdependence seems to exist between TAC and its other suppliers, for example CS and LS. The components are not uniquely designed for TAC, the volumes are relatively low and TAC has several suppliers with the possibility to switch supplier base. Compared to the cases of BM and PM suppliers, there are less strong interdependencies and thus the partners adjust information sharing (compare Danese *et al.*, 2004) and share information less frequently, refrain from implementing advanced IT systems and focus on operational rather than strategic level. Downstream, the market company in Sweden also represents a serial interdependence with low volume and predictable demand patterns. Basically, there is no need to intensify information sharing for TAC to plan production and supply products OTIF to the Swedish market. The current information sharing for the UK market is similar to that of Swedish market. However, considering higher volumes, tailored products and unpredictable demand patterns, the relationship has characteristics of strong, reciprocal interdependence where the partners depend on each other to "get it right" in production and delivery schedules. That is why TAC, who historically focused their information sharing initiatives on upstream partners, recently has initiated a project with selected large markets representing reciprocal interdependencies to develop their inter-organizational business processes and information sharing. Thereby TAC strives to better plan production and logistics activities in order to reduce inventory levels while also providing better service to the selected markets.

5.2 Moving beyond dyadic supply chain relationships: related barriers

Moving beyond the dyadic relationships, the supply chain partners (e.g. TAC and second-tier suppliers; or first-tier suppliers and first-tier customers of TAC) have no direct connection with one another. Without a direct connection, multi-tier partners rarely, if ever, communicate and discuss

business and establish contracts for controlling information sharing initiatives. In Thompson's (1967) terms, the partners make a discrete contribution to the supply chain as a system. Further, it is interesting to note that such partners are part of, and contribute to, the output of multiple supply chains (e.g. TAC's first-tier suppliers have multiple customers). Considering the factors presented by Cox (2004), multi-tier partners seem to represent low percentage of volume and value in each other's portfolios. The products and components tend to not be unique and it is possible to switch to other partners. The above characteristics indicate a weak, pooled type of interdependence between multi-tier partners. As an example, considering TAC's second-tier customer, Tesco is not dependent on having TAC's products on the shelf. In fact, they could decide to throw out the Absolut Citron and replace with another product. Similarly, as for TAC's second-tier suppliers, they supply generic components and raw material and have other major customers and customers' customers that are much larger and more important than TAC.

The above analysis suggests that information sharing in the extended supply chain is impeded by weak, pooled interdependencies between supply chain partners that are not directly connected. To enable multi-tier information sharing in the supply chain, it may thus be required to identify and exploit stronger interdependencies between partners representing multiple tiers, for example by connecting dyads of dyads. One such example from the studied case could be to connect two reciprocal interdependencies, Pernod Ricard UK – TAC and TAC – BM, in order to make it both interesting and feasible to share information. 'Interesting' here means that it makes sense in terms of market share and/or revenues for supply chain partners to share information across multiple tiers. All companies are part of multiple supply chains. With potentially hundreds of suppliers and equally many customers, there is often an issue of each second-tier supplier or customer representing only a fraction of the focal company's turnover. This issue particularly relates to the identified barrier of demand data disaggregation. From that perspective, an interesting context would thus include one or more unique products or components which represent high volumes for all involved partners where switching costs are relatively high. The second aspect regarding 'feasibility' relates to the identified barriers of risk of demand information misinterpretation and the risk of making production and distribution decisions based on incomplete information. To deal with these barriers, and be able to use shared information for decision making, it may be needed to establish direct connections among partners from multiple supply chain tiers (e.g. dyads of dyads) through face-to-face meetings, task forces and integration mechanisms (see Danese *et al.* 2004).

6. Conclusions and implications

This paper seeks to move beyond the commonly researched dyadic relationships and empirically explore demand-related information sharing in a multi-tier, extended supply chain. The study has investigated what information is currently shared in dyadic supply chain relationships, considering also whether such relationships are characterised by reciprocal or serial interdependencies. It has also suggested that information sharing across multiple supply chain tiers can be impeded by weak, pooled interdependencies among partners that are not directly connected. Three key barriers to extending information sharing beyond dyadic relationships were identified in this connection: a) demand information disaggregation, b) risk of demand information misinterpretation, and c) risk of making production and distribution decisions based on incomplete information. Research and managerial implications of these findings as well as limitations and suggestions for future research are discussed in the following sections.

6.1 Research implications

The study contributes to existing literature on information sharing in supply chains in the following ways. Firstly, it stresses the importance and role of reciprocal, serial and pooled interdependence

(Thompson, 1967; Dubois *et al.* 2004) for information sharing, both in dyadic relationships and the extended supply chain. Drawing primarily on Thompson's (1967) seminal work on interdependence types, the paper extends Danese *et al.*'s (2004) and Cox's (2004) work by not only empirically demonstrating how (reciprocal or serial) interdependence influences information sharing patterns in dyads, but also how pooled interdependencies in the extended supply chain can help explain the difficulties of sharing information across multiple tiers. Pooled interdependence among indirectly connected supply chain partners create barriers as the ones identified in this study. Considering those barriers, information sharing should, according to the interviewees, only be considered in particular situations. One such example could be early stage of product life cycle related to TAC's increased rate of new product introductions.

Secondly, the study builds on existing literature advocating a contingent treatment of information sharing in supply chains (e.g. Danese *et al.*, 2004; Samaddar *et al.*, 2006; Grover and Saeed, 2007; Roh *et al.*, 2008; Vanpoucke *et al.*, 2009) by suggesting that information sharing in dyads may need to be adapted considering whether dyadic relationships are characterised by reciprocal or serial interdependencies. More specifically, reciprocal interdependencies appear to be the strongest type (in terms of interdependence intensity) and entail intensive information sharing between dyadic partners, also at the strategic level. In comparison, referring also to Dubois *et al* (2004) and Cox (2004), serial interdependencies are less strong than reciprocal ones and thus information sharing between dyadic partners appears to be focused at the operational level and is less intensive or frequent than in the case of reciprocal interdependencies in the supply chain.

Thirdly, the study makes an empirical contribution to the literature by exploring information sharing across multiple supply chain tiers. More specifically, data from three tiers in the extended supply chain (TAC and its first-tier customers and suppliers) are collected and analysed, an endeavour that has been missing in the empirical literature on information sharing in supply chains. Particularly, this appears to be the first study applying interdependence theory as well as exploring the barriers of information sharing beyond dyadic supply chain relationships (see Kembro *et al.*, 2014).

Fourthly, and in connection to the above, the study contributes to existing literature on barriers of information sharing in supply chains (e.g. Moberg *et al.*, 2002; Li *et al.*, 2006; Fawcett *et al.*, 2007; Klein and Rai, 2009). This literature tends to focus on dyads as its analytical unit. Focusing on the extended supply chain as its unit of data collection and analysis, our study has unearthed the aforementioned barriers to information sharing beyond dyadic supply chain relationships. Considering the barriers related to information misinterpretation and incomplete information, the study stresses the importance of 'meta-information', i.e. information about the information shared. This finding suggest that, in order for information sharing across three or more tiers to be feasible in cases of pooled interdependence, additional information is required to help interpret or complement any shared information.

6.2 Managerial implications

Similar to the findings of this exploratory study, other researchers have noted that companies, in general, refrain from sharing information beyond dyadic ties. Taylor and Fearne (2006, p. 381), for example, conclude from their study that:

"… in none of the chains studied was EPOS data transferred further upstream than the retailer's immediate supplier."

This study has highlighted the role of interdependence in considering the intensity of information sharing. In the cases representing reciprocal interdependence, the partners appear to share information intensively, both on strategic and operational level. Similarly, in cases characterised by less strong, serial interdependencies, the companies seem to limit information sharing initiatives and

restrict them mainly to the operational level. Particularly, moving beyond the dyads the multiplicity of connected relationships entail weaker, pooled interdependencies among supply chain partners. Products and components are seldom unique and represent a low percentage of other partners' turnover. Similarly, there are multiple suppliers and customers and switching costs are in many cases low. Considering these factors, it may only be interesting to engage in multi-tier information sharing in particular cases where dyads of dyads may exhibit strong interdependencies. However, supply chain managers would mostly focus on stronger, reciprocal interdependencies and emphasize dyadic information sharing.

Going back to TAC's concern of unsatisfactorily high inventory levels, the analysis offers some suggestions on how to proceed with managing information sharing. First, there is an opportunity for TAC to increase their focus on downstream partners representing reciprocal interdependencies. By considering the percentage of volume and value that each market represents it is possible to single out important customers. Combined with high uncertainty, a few selected markets including UK seem critical to engage with further for TAC and their suppliers in order to better assign and optimize capacity for production and logistics. Building on, for example, Godsell *et al.* (2011), Cox (2004) and Danese *et al.* (2004), Figure 2 proposes a framework that can be used for conducting a "demand profiling" and adjust information sharing to the type and intensity of interdependence considering volume and value as well as demand uncertainty for different markets. To better describe how the framework can be used, two examples from this study, Pernod Ricard UK (PRUK) and Pernod Ricard Sweden (PR Sweden), are included in the figure.

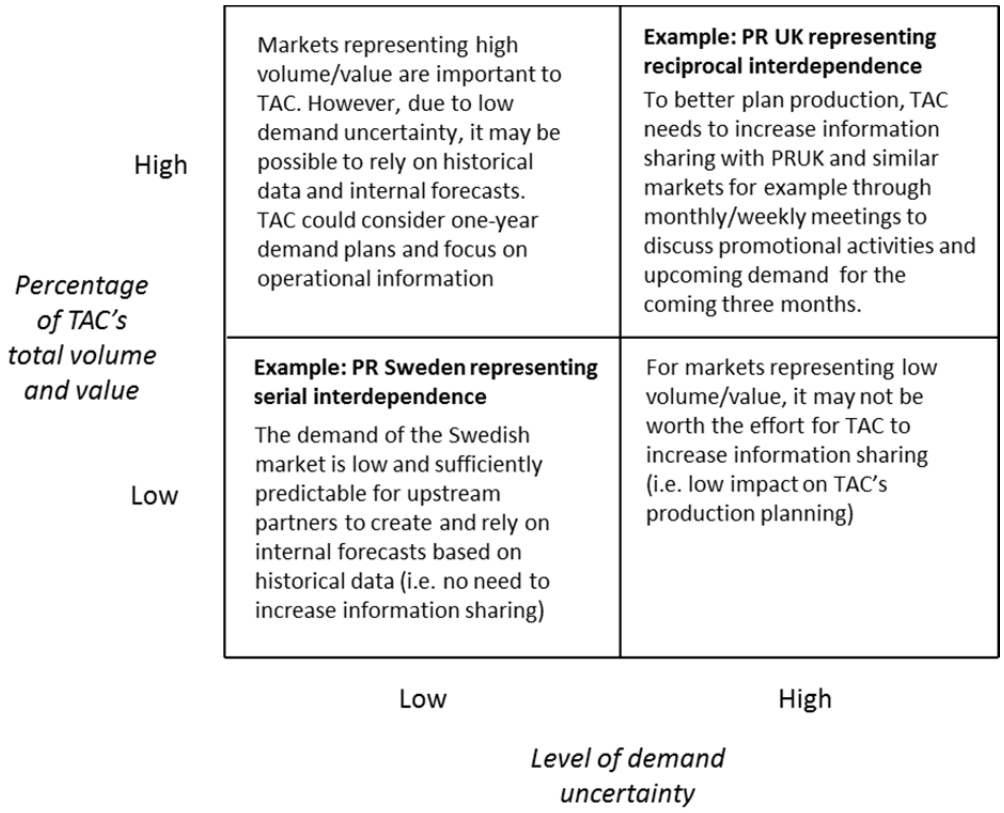

Figure 2 – A framework of "demand profiling" for adjusting level of information sharing to the type and strength of interdependence considering volume and value as well as demand uncertainty for different markets.

Second, having identified strong interdependencies with customers and adapted information sharing accordingly, there is a possibility to focus on strengthening the connections between specific dyads representing reciprocal interdependencies. One example from the case supply chain would be to connect the dyad Pernod Ricard UK and TAC with the dyad TAC and BM by emphasizing the intermediating role of TAC to aggregate and interpret the data sent from Pernod Ricard UK before sending on to BM. Third, despite the identified barriers, it could be worth considering multi-tier information sharing in particular situations. TAC has increased the rate of product launches including limited editions which create a bottle-neck in production both for TAC and its suppliers. Particularly, according to the interviewees, the partners could benefit from collaborating beyond the dyadic ties in the early stages of the product life cycle in order to better match supply with demand. In such cases, TAC, key market companies and suppliers might be interested to engage in multi-tier information sharing. To succeed with such an initiative, it would be necessary for TAC to establish mutual trust and a joint understanding between all partners and to ensure that appropriate mechanisms of sharing related risks and benefits (including financial gains resulting from information sharing) are in place.

6.3 Limitations and future research

Despite its strengths, this exploratory study has certain limitations that should be considered in the interpretation of the findings. The study is based on a single, embedded case study focusing on a single product. It follows that further empirical research is needed for generalizing the findings to other supply chain contexts.

Extending the findings of this study can be done for example by conducting a multiple case study considering both functional and innovative products (Fisher, 1997) as well as multiple markets representing different volumes and levels of demand uncertainty. Also, the emphasis in this study on production in the focal company and the upstream supply chain should be taken into consideration. It would be a worthwhile project to investigate and compare information sharing in networks of producing companies versus downstream distribution channels.

Another avenue to extend the findings and further explore multi-tier information sharing would be to apply the Delphi study method. The Delphi study is a systematic process for reaching a consensus view from a panel of experts on a complex topic (Linstone and Turoff, 2002) and can, for example, be used to investigate factors influencing decision-making on a specific issue, topic or problem area (MacCarthy and Atthirawong, 2003). Building on this study, the Delphi study could thus be useful to increase our understanding of different contextual factors that have an impact on information sharing in supply chains. Particularly, considering the perspective of contingency theory (Woodward, 1965; Donaldson, 2001), it would be valuable to increase our knowledge of how different factors impact benefits versus feasibility of implementing information sharing across multiple supply chain tiers. Related, it would be worthwhile to further investigate the underlying barriers to multi-tier information sharing.

Finally, taking into consideration that supply chains can be construed as networks of relationships, future research could further explore the impact of the notion of connectedness in relation to inter-organizational information sharing. Connectedness, originating in social exchange theory (see Cook and Emerson, 1984), recognizes that all relationships have indirect effects on other business relations within the broader network and, therefore, all firms as well as their respective productive activities and resources interrelate to one another, at least to some extent (Anderson et al., 1994; Gadde, 2014). One opportunity would thus be to extend the findings from this study and investigate how embedded networks impact inter-organizational information sharing. Another opportunity, from the

perspective of interdependence theory, would be to identify supply chain contexts where reciprocal interdependence exists among dyads of dyads or across three or more tiers.

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APPENDIX: INTERVIEW GUIDE

1. Physical flows: Describe the physical flows for products/components handled in relation to *The Absolut Company*.
2. Information flows: What information do you share with suppliers (and suppliers' suppliers) / customers (and customers' customers) on a strategic/tactical/operational level, and what are the related benefits?

(Related to three organizational levels and respective decision time horizon: strategic (beyond 6 months) for example forecasts, market trends, ability to grow; tactical (2 weeks – 6 months) e.g. material requirement planning, safety stock and allocation of capacity; operational (less than 2 weeks) e.g. order status, inventory levels, lead times, production schedules).

3. Do you share different types/amount of information with different suppliers/customers? If yes, please describe and explain why.
4. Do you wish to increase/extend information sharing with any of your suppliers/customers? If yes, what type of information, with whom and why?
5. Related to question 4, are there any challenges to increase/extend information sharing? Particularly, what are the barriers of sharing information beyond dyadic supply chain relationships?