

UNIVERSITY OF TWENTE.

# Master Thesis

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Factors influencing multi-tier supply chain  
information sharing: a multi-tier supply chain case  
study

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## Abstract

Supply chain information sharing (SCIS) becomes more important due to the increased vulnerability of supply chains. Implementing lean practices, increasing outsourcing, and globalization, increases vulnerability of supply chains. Therefore, the aim of this paper is to find the factors that limit and facilitate SCIS. The practical relevance of this paper is to create awareness of the limiting and facilitating factors of SCIS per tier of the supply chain. This enables them to reduce the limiting factors in their supply chain and increase the quality, and quantity of shared information within their supply chain.

**The Method:** Based on the structured literature research the theoretical framework is constructed. This theoretical framework is tested in a case study. The case study is conducted in a supply chain of a Dutch Manufacturer of animal pharmaceuticals, animal healthcare products, and foods for pets

The main findings of the research are that SCIS has a positive effect on the performance in the supply chain. Moreover, a key finding of this research is that the factors that limit SCIS can be divided into the four aggregate dimensions, connectivity, individual willingness, supply chain characteristics, and organizational facilitation. The factors that influence SCIS do not differ per tier of the supply chain. Even though different tiers request, share, and use different types of information. However, there is a difference between strategic and operational information sharing is found

The practical aim of the paper is to provide managers insight into which factors limit and facilitate information sharing in their supply chain. This paper provides a framework with the aggregate and 2nd sub-factors that limit and facilitate information sharing. The framework is only tested on one supply chain. Subfactors might be different per supply chain and per sector. However, it is expected that different supply chains will have the same four aggregate dimensions.

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## Index of abbreviations

Abbreviation	Full text
IoT	Internet of Things
CPS	Cyber Physical Systems
SCIS	Supply chain information sharing
ISI	Internal information sharing
ISC	Information sharing with customers
ISS	Information sharing with suppliers
TDI	Timely demand information
ERP	Enterprise Resource Planning
POS	Point-of-Sale
DSC	Digital Supply Chains

# **1. Introduction: Increasing importance of SCIS due to increased supply chain vulnerability**

In recent years firms increased their focus on supply chain efficiency by implementing lean practices and increasing outsourcing, and globalization. This increased vulnerability of supply chains (Sharma et al., 2021) Moreover, Abdel-Basset and Mohamed (2020) state that the increasing global competition, sustainability goals, and the complexity of the supply chain structure increases its vulnerability. In addition, an industrial revolution is occurring. With the introduction of the Internet of Things (IoT) and Cyber-Physical Systems (CPS) the industry is undergoing a significant change (Wollschlaeger et al., 2017). This industrial revolution is often referred to as Industry 4.0. With increased and more advanced technology, more and wider interconnection between external partners is possible (Wollschlaeger et al., 2017). Frohlich and Westbrook (2001) found that manufacturer and supplier information sharing has a positive influence on operational performance. (Huo et al., 2014) state that information sharing between the manufacturer and customer has a positive effect on the quality and delivery reliability of the manufacturer. In addition, Simatupang and Sridharan (2008), state that information sharing with the members of the supply chain enables effective decision making. Another benefit of information sharing across the supply chain is that it enables monitoring and controlling of the progress of the products in each stage of the supply chain (Simatupang and Sridharan 2008) . Strader et al. (1999) found that information sharing reduces uncertainty in a supply chain. (Chen et al., 2000) found that information sharing can reduce but not eliminate the bullwhip effect. The bullwhip effect is the increased variance of safety stock in the downstream orders in a supply chain (Lee et al., 1997) . So past research has shown that information sharing increases supply chain performance. However, little is known about which information should be shared by which tier of the supply chain. Besides, there is resistance from managers to share information beyond their own firm. The cost of implantation is seen as a reason for resistance. In addition, the fear of sharing confidential or sensitive information is seen as a barrier for information sharing with supply chain partners (Fawcett et al., 2008). Furthermore, different goals and unfair distribution of rents are seen as barriers to information sharing (Fawcett et al., 2008) .

With the introduction of Industry 4.0 new information sharing opportunities are there to be discovered. Industry 4.0 can best be described a shift in manufacturing logic toward a technology steered, decentralised, self-regulating approach to value creation, (Hofmann &



Rüsch, 2017) As industry 4.0 can enhance information sharing and remove the resistance of information sharing. Such an example is the machine-to-machine communication which leads to reduces confidentiality issues as no human interaction is required. Moreover, more information becomes available due to the accessibility and affordability of sensors, data storing and data acquisition systems, and computing power (Lee et al., 2015) . However, it seems SCIS is not fully used. This research is interested to test which factors influence the level of SCIS and if they differ per tier of the supply chain. In addition, this research is interested if Industry 4.0 will have an interactive effect on the factors that influence the level of SCIS. The following central research question is formulated.

### **Which factors influence the level of information sharing among tiers in a multi-tier supply chain?**

To answer the central research question, the following sub-questions have been formulated:

- Which factors limit supply chain information sharing?
- How will industry 4.0 influence the factors which influence information sharing?
- To what extend do factors differ between types of information

In this research existing literature regarding supply chain structure, supply chain information sharing (SCIS), and existing research conducted on industry 4.0 will be used to create the framework.

The academic relevance of this paper is that this research differentiates the tiers of a supply chain, were other research on SCIS does not differentiate between tiers in the supply chain. In addition, this paper differentiates between types of information, strategic and operational information flows. Thus, the academic relevance of this paper is to see if different tiers of a supply chain need different types of information and have different factors that influence SCIS. With the upcoming industrial revolution, industry 4.0, this research is interested if the introduction of Industry 4.0 will have an interaction effect on the factors that influence SCIS. Existing literature found that SCIS enables the members of the chain to capture, store, and provide information that allows effective decision making (Simatupang & Sridharan, 2008). Chen et al. (2000) found that sharing customer demand information throughout the supply chain reduces the magnitude effect of the bullwhip effect. Fawcett et al. (2009) found that SCIS significantly increases operational performance based on a resource-based view. Thus, existing research on SCIS mainly focuses if SCIS has a positive on supply chain performance. Yet current literature is lacking on the difference between the multiple tiers in a

supply. In existing literature no differentiation is considered on the information shared to suppliers, manufactures, and retailers nor on a multi-level supply chain information sharing. This research adds new insights to the difference in factors that limit and facilitate information sharing in a multi-tier supply. Thus, this paper aims to fill this gap of generalization on information sharing between supply chain tiers.

The practical relevance of this paper is to provide supply chain managers with information on which factors limits SCIS. This to enable them to reduce the limiting factors in their supply chain. Thus, this paper aims to find which factors limits and facilitate information sharing per tier. Therefore, a practical relevance of this paper is to create awareness of the limiting factors of SCIS per tier of the supply chain. Furthermore, this paper aims to help supply chain managers to understand the benefits of industry 4.0 and information technology on SCIS. This is of use when the firms start to implement industry 4.0 as this can improve the infrastructure of industry 4.0 during the implementation phase.

The paper is structured as follows, it starts with the theoretical framework (chapter 2), where current literature regarding supply chain structure, supply chain performance indicators, benefits, and barriers of SCIS, information technology, and industry 4.0 is reviewed. Based on the existing literature a conceptual framework is provided. The third chapter of this paper is the methodology section. In this section of the paper the research design is provided based on who, how, why what, and where. Along with the description of the sample group and. Finally, in this part of the paper, the data collection procedure and data analysis methods will be explained. In the fourth chapter of the paper, the results of the empirical research will be provided. Finally in the fifth, and final chapter, the discussion and conclusion are provided. This part includes key findings, limitations, future research, and the practical implications for organizations.

## 2. Past research; SCIS and the emerging influence of industry 4.0

In this part of the paper, past research and literature are used to describe and outline the key topics of the paper. These include supply chain structure, supply chain performance indicators, benefits, and barriers of SCIS, information technology, and industry 4.0. Based on this part, the conceptual framework will be created.

### 2.1 Supply chain is the connected network of interdependent organizations which include supplier tiers, manufacturer, distributor, and retailer.

Supply chain management is defined as a connected network of interdependent organizations which are mutually and cooperative and work together in order to control, manage and improve the flow of materials and information from supplier to the end customer (Lambert et al., 1998). The definition of Lambert et al. (1998) is relatively similar to the definition of Aitken (1997) who describes supply chain management as follows “a network of connected and interdependent organisations mutually and cooperatively working together to control, manage and improve the flow of materials and information from suppliers to end users” (p.16). Ellram (1991) defines supply chain management as “an integrative approach to dealing with the planning and control of the materials flow from suppliers to end users” (P.1). Moreover, to pursue a supply chain, Ellram and Cooper (1993) state that cooperative management and controlled distribution channels benefit all supply chain members and maximize efficient use of resources while achieving customer service goals.

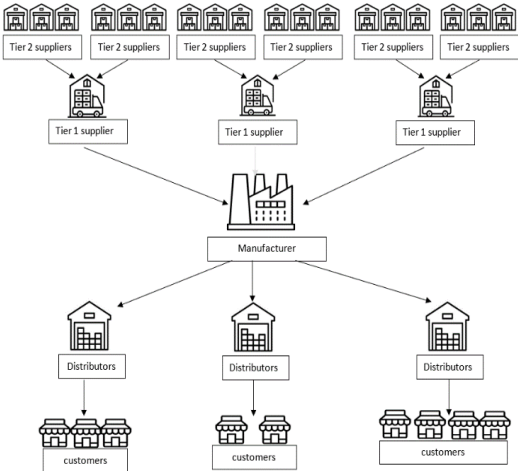


Figure 1 Simplified Keiretsu supply chain (Ellram & Cooper, 1993)

The most common supply chain management structure is based on the Japanese Keiretsu structure. Keiretsu is a pyramidal structure of the supply base with tiered arrangements which has the aim to reduce the number of suppliers of the assembler/manufacturer (Ellram & Cooper, 1993). The direct suppliers of the manufacturer are often called tier-one suppliers or

system integrators, the suppliers of tier-one suppliers are often called tier-two suppliers. Keiretsu relies on cooperation, coordination, information sharing, and joint ownership by the supply chain partners and is often controlled by the manufacturer (Bhattacharya et al., 1996). Figure 1 provide a simplified supply chain based on the Keiretsu structure. Bhattacharya et al. (1996) describes the value boundaries of the tiers in the supply chain. The product owner also called manufacturer or assembler, has the tasks to design the product, develop few technologies, and assemble sub-assemblies (systems). The Primary supplier also called tier-one suppliers or system integrators have the task of, system design, make components, develop technology, assemble into systems, quality assurance and deliver per schedule. Secondary suppliers also called tier-two suppliers design and make components, (sub)assemble, develop technology, quality assurance and deliver per schedule to the manufacturer. The distributors have the task to store and supply the products to the retailers or customers (Ellram & Cooper, 1993).

## **2.2 Supply chain performance indicators are efficiency of resources, supply chain output and supply chain flexibility**

Measuring the performance of a supply chain is important as it allows partners to continuously evaluate, manage and control activities to achieve the objectives of the chain (Simão et al., 2021). However, measuring the performance of a supply chain is complex as it deals with multiple individual entities (Mishra et al., 2018). Beamon (1999) supply chain measures are still seen as valid as they are often used in more recent papers (Mardani, et al. ,2020) and (Frederico et al., 2021). Performance measurement for supply chains in the industry 4.0 era: a balanced scorecard approach. However, more recent papers on supply chain performance focus on sustainable measures (Tajbakhsh & Hassini, 2015; Ferreira et al., 2016). Therefore, this paper the performance indicators of Beamon (1999) will be used. Yet, sustainable performance indicators will be added.

According to Beamon (1999), supply chain performance can be measured based on the three types of performance indicators. These three indicators are resource efficiency, output, and flexibility. Resource measurement aims to measure the efficiency of the used resources. The efficiency is the minimum requirements or quantity needed to meet the objectives. Too few resources may influence the output negatively while too many resources reduce efficiency. The resource measures include inventory levels, personnel requirements, equipment utilization, energy usage, and cost. The following measures can be used to measure the resource performance of a supply chain:

- Total cost of used resources
- Total cost of distribution (both handling and transportation cost)

- Manufacturing cost (including labour, maintenance, and re-work cost)
- Cost associated with held inventory (including, value of held inventory and cost of obsolescence)
- Return on investment (ROI)

The second Beamon's (1999) supply chain performance measure is output. This measure aims to measure customer service and the quality of the supply chain. Output includes the number of items produced, the time required to produce, number of on-time deliveries, customer satisfaction, and quality. Beamon's (1999) Output performance measures are:

- Sales (total revenue)
- Profit (total revenue less expense)
- Proportion of ordered filled immediately
- On-time delivery
- Backorder/stockout levels
- Customer response time (amount of time between an order and its corresponding delivery)
- Total amount of time required to manufacture an item or batch
- Number of incorrect shipments
- Number of customer complaints

The final indicator of Beamon's (1999) supply chain performance measures is flexibility which refers to the ability to respond to a changing environment. In a flexible supply chain, the system can adapt to volume and schedule fluctuations from suppliers, manufacturers, and customers. Beamon (1999) uses Slack (1988) four types of flexibility which include (i) Volume flexibility which is the ability to change the number of products produced (ii) delivery flexibility, which is the ability to change delivery dates (iii) mix flexibility, the ability to change the variety of products produced (iv) product flexibility which refers to the ability to introduce and produce new products or modifications on existing products (Slack, 1988).

As mentioned, more recent research uses similar indicators as Beamon (1999), however, the additional indicator towards sustainability performance indicators is added. Sustainability performance indicators can be divided into social aspects and environmental protection (Tajbakhsh & Hassini, 2015). Environmental aspect indicators include dependence on solid fuel, efficient use resources, environmental damages due to enterprise operation, water consumption, amount of omitted CO<sub>2</sub>, percentage of renewable energy (Tajbakhsh & Hassini, 2015). The social aspects can be measured with the indicator's diversity, health and safety, child labour, and community involvement and contribution (Tajbakhsh & Hassini, 2015).

## **2.3 Supply chain information sharing is a concept toward supply chain performance**

In this part of the literature review supply chain information based on existing literature is explained. This part includes research on the types of information shared and the factors that influence the decision to share and request information.

### **2.3.1 SCIS is the sharing of a variety of strategic and operational information with supply chain partners**

Traditionally the actual order was often the only information firms exchanged between supply chain partners. However, due to the increase in information sharing technology, firms are now able to share information such as demand, POS data, disruptions, and inventory data in a quick and inexpensive manner (Cachon & Fisher, 2000).

Cao et al. (2010) describe sharing information as the extent to which firms share a variety of relevant, accurate, complete, and confidential ideas, plans, and procedures with their supply chain partners in a timely manner. Prajogo and Olhager (2012) define that the supply chain exists of two flows namely a flow of goods and a flow of information. Moreover, Prajogo and Olhager (2012) explain Information integration as the sharing of key information with all members of the supply chain. Information integration aims to achieve real-time transmission and processing of information required for supply chain decision making (Prajogo & Olhager, 2012). Sahin and Robinson (2002), define that no information sharing is when the supplier only receives information based on the actual orders it receives from the buyer. In an information sharing supply chain, information such as production status, cost of production, transportation availability, quantity discounts, inventory costs, inventory levels, capacities, demand data from all members of the supply chain, and planned promotional activities. In a full information sharing supply chain, each partner of the supply chain has quick and easy access to the information of their supply chain partners.

According to Prajogo & Olhager (2012), there are two types of information sharing namely forward and backward. Forward information sharing refers to the information shared from supplier to manufactures, so in the same direction as the flow of goods. Backward information sharing refers to the sharing of information from the manufacturer to their suppliers or customers to manufacturers. Huo et al. (2014) defined that there are three types of supply chain information sharing (SCIS) namely, internal information sharing (ISI) Information sharing with customers (ISC) information sharing with suppliers (ISS) Information. Internal information sharing (ISI) is the sharing of information among the internal function of the manufacturer. A reliable ISI flow is helpful to establish information sharing with customers

(ISC) and with suppliers (ISS) ISI often includes the manufacturing plan, source, make, deliver, source return, and deliver return processes of a manufacturer. Kim and Narasimhan (2002) found that ISI is positively related to supply chain performance. ISI can help to reduce cost, shorten lead times, and improve quality and customer service levels. Information sharing with suppliers (ISS) is related to the flow of information between the manufacturer and the supplier and from the supplier to the manufacturer. Often the flow of information in ISS includes sharing of production schedules, inventory status, inventory planning, demand, and forecasts information with suppliers. Frohlich and Westbrook (2001) studied that ISS has a positive effect on supply chain performance. Based on the research among 890 UK firms, Frohlich and Westbrook (2002) found that supplier integration has a positive influence on operational performance. The same was found in a study with 120 US manufacturing firms. This study was conducted by Devaraj et al. (2007) Information sharing with customers (ISC) focuses on the links between the manufacturer and the customer. Often shared information between the manufacturer and customer is the demand forecasts and customer needs. The aim of ISC is to quickly understand the changing requirements of the customers. This enables the manufactures to react more quickly and reliably offer them more customized products and services while reducing lead times and inventory costs. Moreover, according to Huo et al. (2014) ISC can also improve quality and delivery reliability.

Table 1 provided below is a consolidation of the types of information sharing with a positive effect on supply chain performance found in existing literature. These types are divided into strategic information and operational information. According to Qi and Qingyu (2010) information sharing can be divided into operational information and strategic information (Qi & Qingyu, 2010a). Operational information are the information flows that are based on short-time activities which are likely to fluctuate. Operational information is often used by lower-level employees to ensure the continuous flow of goods (Qi & Qingyu, 2010a). According to Qi and Qingyu, (2010) operational information improves performance of both upstream and downstream supply chain partners. Strategic information is information of long-time plans which are often decided on monthly, annual, or longer terms and are less likely to fluctuate. Strategic information is often used by Management to plan for longer periods. Qi and Qingyu, (2010) state that strategic information has the purpose to establish a long-term partnership and commitment among the supply chain partners. Strategic information involves the highest management levels of the organizations. Based on the existing literature, five types of strategic information are found namely, Production information, Product information, Demand information, Sales forecast, Market information. Also, the types of operational information is

divided into five groups namely Production status, Lead-times, Inventory levels, Sales information, Disruption notifications.

Table 1 Types of information sharing

Information sharing types	Author#	(Datta & Christopher, 2011)	(Simatupang & Sridharan, 2005)	(Yu et al., 2010)	(Cachon & Fisher, 2000)	(Gavimani et al., 2011)	(Frohlich & Westbrook, 2001)	(Kulp et al., 2004)	(Lancioni et al., 2002)	(Lee et al., 2000)	(Krajewski & Wei, 2001)	(Li & Lin, 2006)	(Huo et al., 2014b)	(Zhou & Jr, 2008)	(Kembro & Selvaridis, 2015)	(Dwaikat et al., 2018)	(Sahin & Robinson, 2002)	(Omar et al., 2010)	(Lin, 2009)	(Li, Lin, Wang, & Yan, 2006)
	Author#	(Datta & Christopher, 2011)	(Simatupang & Sridharan, 2005)	(Yu et al., 2010)	(Cachon & Fisher, 2000)	(Gavimani et al., 2011)	(Frohlich & Westbrook, 2001)	(Kulp et al., 2004)	(Lancioni et al., 2002)	(Lee et al., 2000)	(Krajewski & Wei, 2001)	(Li & Lin, 2006)	(Huo et al., 2014b)	(Zhou & Jr, 2008)	(Kembro & Selvaridis, 2015)	(Dwaikat et al., 2018)	(Sahin & Robinson, 2002)	(Omar et al., 2010)	(Lin, 2009)	(Li, Lin, Wang, & Yan, 2006)
<b>Strategic information</b>																				
Production information	Operating cost		X																X	
	Production plans	X				X	X		X		X	X	X	X	X	X		X		
	Production Capabilities		X										X							
Product information	Product life cycle plans		X																	
	Product portfolio	X	X												X	X		X		
	(New) Product information	X					X						X	X	X		X			
Demand information	Replenishment order point	X			X													X		
	Demand forecast		X	X														X		
Sales forecast	Annual Sales Forecast	X	X			X	X			X			X	X		X		X		
	Promotion schedule		X										X	X		X	X			
Market information	Market changes		X										X					X		X
	Customer needs	X	X					X										X		
<b>Operational information</b>																				
Production status	Production capacity		X	X									X	X					X	
	Availably of resources		X										X					X		X
Lead-times	Lead Times		X															X		
	Status of process (tracking)		X										X		X				X	
	Delivery schedule		X			X							X					X		
Inventory levels	Inventory levels	X	X	X	X	X		X	X	X		X	X	X		X	X	X	X	X
	Current demand	X	X	X	X	X	X	X		X		X	X	X		X	X	X	X	X
	Resource planning		X															X		
Sales information	Order status							X					X	X	X	X		X		X
	Point of Sales data	X	X		X				X			X					X	X		X
	Short term sales Forecast	X	X		X	X			X			X	X		X		X			
Disruption notifications																				



### **2.3.2 SCIS enables members to capture, store, and provide information to supply chain partners which improves decision making.**

According to Simatupang and Sridharan (2008), Sharing information throughout the members of the supply chain enables the members of the chain to capture, store, and provide information that allows effective decision making. Moreover, SCIS enables members of the supply chain to monitor and control the progress of the products of each process within the supply chain. Chen et al. (2000), state that when customer demand information is visible for every member of each stage of the supply chain it significantly reduces the magnitude of the bullwhip effect. However, it does not eliminate the bullwhip effect. The bullwhip effect (also called whiplash effect) which refers to the phenomenon where orders to suppliers tend to have a larger variance than their downstream orders from their buyers. The increased variance is often called demand distortion. Thus, due to amplified demand patters, the variances of orders amplify as it moves up in the supply chain. The bullwhip effect leads to inefficiencies in the supply because of excess inventory, poor customer service levels, and loss of revenue (Lee et al., 1997). Strader, Lin, & Shaw (1999) found that sharing supply and demand information throughout the supply chain reduces uncertainty. Reduced uncertainty in a supply chain means that less inventory is needed while keeping cycle times similar (Strader et al., 1999). The lead time information of different suppliers can be used for planning purposes of the manufacturer. When lead times are communicated, less inventory building is needed to fulfil orders. Moreover, when demand information of the customer is communicated to the manufacturer in a timely manner, order fulfilment can become more efficient as less safety stock is needed (Strader et al., 1999). Kim and Chai, (2017), found empirical evidence that SCIS has a positive effect on improving supply chain agility. Moreover, according to Kim and Chai (2017) SCIS has a positive effect on supplier collaboration, builds better partnerships, and promotes integration between different suppliers in the supply chain. Fawcett et al. (2009) found that SCIS significantly increases operational performance, based on a resource-based view, and customer satisfaction. Lee et al. (2000) state that sharing information has a positive effect on reducing inventory levels and reduces lead time. Moreover, sharing information has a positive effect on reducing the overall cost of the manufacturer. A moderating effect found by (Lee et al., 2000) was the amount of fluctuation in the demand and the lead times of the products. In a highly fluctuating demand environment information sharing has a higher effect on reducing overall cost. Also, information sharing is more beneficial for manufacturers who are working with products with longer lead times. Bourland et al. (1996) state that timely demand information (TDI) increases fill rate. The fill rate is the probability that the demand for a product is available without backorders or

lost sales. The effect of TDI on the fill rate is moderated by the variability of the demand. In a highly flexible demand environment, the effect of TDI on the fill rate increases. (Bourland et al., 1996)

SCIS can help to update information and can improve understanding of the needs of supply chain partners. SCIS can help to acquire and absorb external knowledge to redesign products/services quickly and effectively, restructure processes to meet customer's requirements in a rapidly changing environment (Huo et al., 2014). In addition to understanding the needs of the supply chain partners, Huo et al. (2014) state SCIS enables manufactures to react more quickly to customers' changing needs and helps them to offer more customized products and services more reliably at a lower cost. Finally, Huo et al. (2014) mentioned that SCIS can help to reduce lead times, reduce inventory costs, and improve quality and customer services in a dynamic competitive environment.

### **2.3.3 The connectivity, chain characteristics, and organizational facilitation are the factors that influence the level SCIS**

However, not all benefits of SCIS are used across many supply chains. In this part of paper, the factors that limit and facilitate SCIS are provided.

According to Kembro et al. (2017) there are 22 factors that challenge external information sharing. These 22 factors are grouped into six categories namely, information utilization, technology utilization, power structures, culture, business process, and legal. Frohlich and Westbrook (2001) mentioned that the cost of IT implementation is seen as a barrier for SCIS. Moreover, supply chain partners may use different systems which increases the difficulty and cost of SCIS implantation. Fawcett et al., (2007) found that connectivity, asymmetric power in a supply chain, and willingness are seen as critical for the implantation of SCIS. According to Fawcett et al., (2009), some mangers consider SCIS as a disadvantage of the firm as they worry that other members of the supply chain might use the sensitive information against the firm. A high level of willingness to share information in a supply chain creates a sustainable and non-imitable competitive advantage. Because the ability to purchase the information technology is relatively easy and can be replicated by competitors (Fawcett et al., 2009). However, creating a supply chain culture which is willing to share information is hardly replicable for competitors thus creates a more sustainable and non-imitable competitive advantage. In addition, Magnan, and McCarter (2008) found that common goals and unfair distribution of rewards are limiting the implantation of information sharing in a supply chain. Both Frohlich, (2002) and Porterfield et al. (2010) and mention that the fear of losing control of sensitive or confidential information is seen as a barrier to the implementation of SCIS.

According to Khurana et al. (2011), barriers towards SCIS can be divided into six main factors namely, managerial, organizational, technological, individual, financial, social, and cultural. The managerial barriers include the lack of realization of the benefits of information sharing, lack of trust and or confidence in information sharing system. Meaning that the managers are not willing to invest in SCIS supporting technology nor creating a SCIS enhanced culture (Khurana et al., 2011). In addition to a limited understanding of the benefits, Khurana et al. (2011) states that managers lack training and experience about new technology. Organizational barriers are the barriers that come from the attitudes of the organization towards SCIS. The interest of employees to share information is lower when they do not enjoy the freedom due to limited empowerment and (Khurana et al., 2011). Khurana et al. (2011) states that high level of bureaucracy and strict administrative control reduces SCIS. Also, formal rules, guidelines, procedures, and regulations are seen as organizational barriers towards SCIS (Khurana et al., 2011). Finally, top management support is suggested to play an important role in the level of SCIS (Khurana et al., 2011). The third barrier of Khurana et al. (2011) is the financial constraints. The financial constraints are mostly related to the willingness to invest in SCIS infrastructure. As stated above, information technology implementation is seen as one of the most important barriers of SCIS (Frohlich & Westbrook, 2001), therefore Khurana et al. (2011) suggest that financial constraints are limiting the level of SCIS. A lack of advanced information technology is seen as a barrier of SCIS (Khurana et al., 2011). Because information technology increases the ease of SCIS and had provided improved methods to share and integrate information. It is suggested that a lack of IT is a result of other barriers such as, financial constraints, lack of knowledge, and lack of top management commitment (Khurana et al., 2011). The fifth barrier identified by Khurana et al. (2011) is individual barriers, these barriers are form the behaviour and actions of the individuals, groups of business department. Individual barriers or willingness to SCIS might be the most important barrier to overcome. Because, if individuals are not willing to share information with supply chain partners, other investments, and efforts to support SCIS do not have an effect on the level of SCIS (Khurana et al., 2011). Kolekofski and Heminger (2003) state that information is seen a symbol of power. As a result, individuals may see sharing as losing power and social influence in the supply chain. The final identified barrier toward SCIS of Khurana et al. (2011). is the social-cultural barrier which refers to the cultural gap between different stakeholders. Mentioned examples of social cultural barriers are, different values, level of education, cultural and linguistic environment. Als diverse missions, goals and priorities are seen as a social-cultural barrier. Moreover, the lack of commitment, involvement of employees is considering as a social cultural

barrier by Khurana et al. (2011). Li and Lin (2006) divided the factors that influence SCIS into the three groups environmental uncertainty, intraorganizational facilitators, and inter-organizational relationships. Environmental uncertainty is defined as the external force that drive information sharing in a supply chain. Environmental factors that influence SCIS are the unpredictability of the customers' demands, unreliability supplier influence supply chain performance, and the development of IT(Li & Lin, 2006). Intra-organizational relationships are defined as the facilitators from inside the organization, according to Li and Lin (2006), intra-organizational facilitators are the support from top management to provide vision, guidance, and support in SCIS. In addition to top-management support, the level of information technology is in intra-organizational facilitator that influences the level of information sharing (Li & Lin, 2006). Finally, inter-organizational relationships refers to the level of trust, commitment, and shared vision between supply chain partners (Li & Lin, 2006).

Different researchers divide the influencing factors differently, some researchers have more groups while other combine more factors into one group. However, most factors are relatively similar. Therefore, in this research the factors are divided into the categories, Connectivity, Chain characteristics, and willingness to share. In this research, the factors that influence SCIS are divided as shown in table 2 below.

Table 2 Factors influencing SCIS

<i>Group</i>	<b>Factor</b>
<b><i>Connectivity</i></b>	Information technology utilization Technological understanding Standardized data format Intercompany connectivity Data and information security
<b><i>Chain characteristics</i></b>	Distribution of power Distribution of rewards Supply chain partner relationships Different values, cultures, and linguistics Diverse missions, goals, and priorities Level of trust in supply chain partners Dependencies between firms Customer uncertainty Supplier uncertainty
<b><i>Organizational facilitation</i></b>	Top-management support Information utilization Information sharing culture Lack of perceived benefits of SCIS Fear of losing control of sensitive or confidential information Rules, guidelines, and procedures Financial resources for operational expenditure

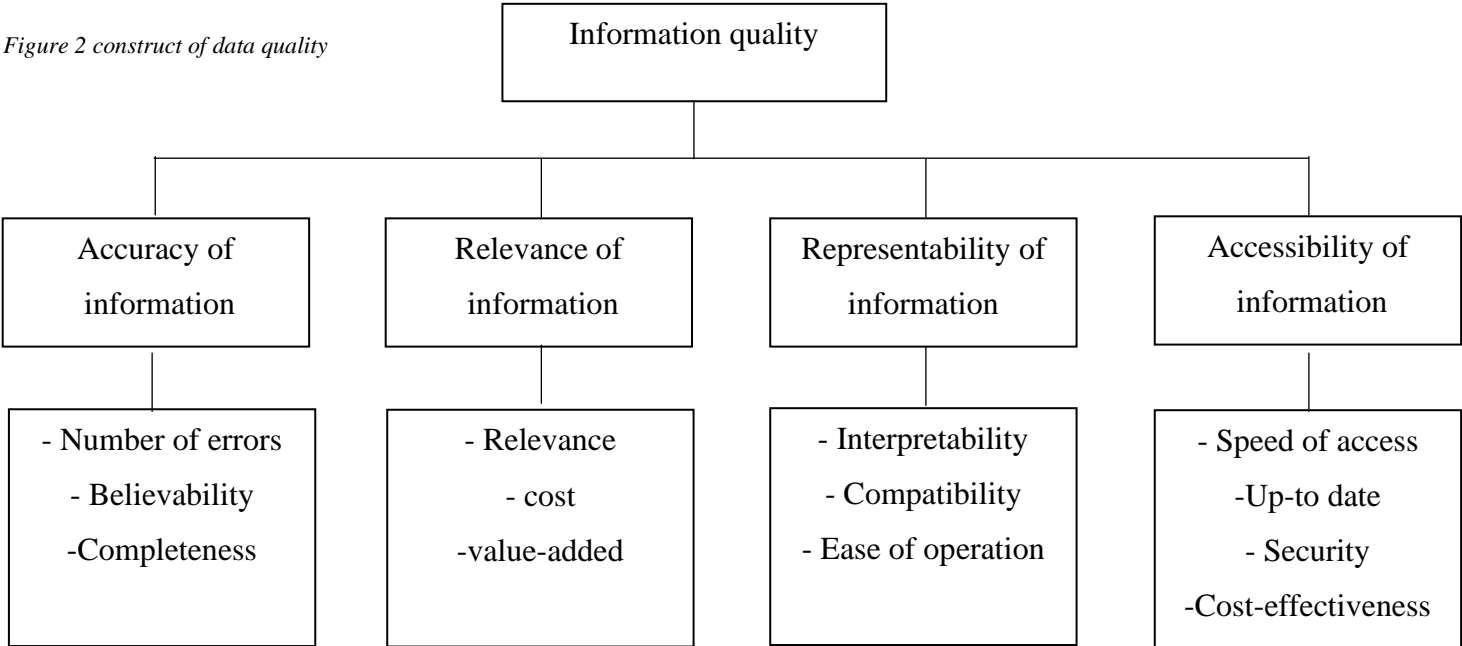
### **2.3.4 Information quality increases supply chain performance, the quality of information can be measured based on four dimensions**

Information quality facilitates good relationships between the buyer and the supplier which increases performance (Zailani et al., 2009). Thus, not only the amount of information shared between supply chain partners is of importance, also the quality of the shared information.

Information quality measures to what extent the shared information between organizations meets the needs of the organization (Qi & Qingyu, 2010a). According to Qi and Qingyu (2010) Supply chain information is useful when the information is high quality, readily accessible, accurate, and relevant. The quality can be evaluated based on the characteristics, accuracy, recency, and frequency (Qi & Qingyu, 2010a). Where accuracy refers to the percent of error in the information. Whereas recency refers to the delay between the occurrence and the presentation of the information. Frequency refers to the time between two sequential pieces of information (Qi & Qingyu, 2010b). Naumann and Rolker (2000) state that the quality of information is one of the most important aspects of information integration. However, information quality is difficult to assess or measure. Naumann and Rolker (2000) divide information quality into the three assessment classes subject criteria, object criteria, and process criteria. Subject criteria include the information that can only be determined based on the personal views, experience, and background of the users of the information. Subject criteria include believability, Concise representation, interpretability, relevancy, reputation, understandability, and value-added (Naumann & Rolker, 2000b). Object criteria the completeness, objectivity, cost, reliability, security, timeliness, and verifiability of the information (Naumann & Rolker, 2000a). Finally, Naumann and Rolker (2000) define process criteria as the process of querying which includes accuracy, amount of data, availability, consistent representation, latency, and response time. According to Wang and Strong, (1996) the quality of information is a construct with the four dimensions Intrinsic, Contextual, Representational, and accessibility. Intrinsic refers to the believability, accuracy objective and reputation of the data. Contextual is the measure of relevance, value-added, timelines, and completeness of the information. Representational is the level of interpretability, understandability, and consistency of the presentation. The fourth and final dimension is accessibility which refers to the ease of access and the level of security (Wang & Strong, 1996b). Based on the similar definition used in existing literature (Naumann & Rolker, 2000; Wang and Strong, (1996) the construct of quality of information can be divided into segments namely, accuracy of information, relevance of information, respectability of information, and accessibility of information. Accuracy of information is defined as the correctness of the

information based on completeness, number of errors, and believability which is similar to Naumann and Rolker (2000) subject criteria and to Wang and Strong's (1996) dimension Intrinsic. The second dimension is relevance of information, which is mostly based on the contextual dimension of Wang and Strong's (1996). This dimension refers to the relevance, cost, and added value of the informant. Representability of information is the interpretability, compatibility, and ease of operation of the information. This dimension is like Wang and Strong's (1996) representational dimension and to Naumann and Rolker (2000) process criteria. Finally, accessibility of information includes the accessibility, up-to-date, society and cost-effectiveness of the informant which is similar to the definition process criteria of Naumann and Rolker (2000) and to the dimension, accessibility of wang and Strong's (1996). figure 2 below shows the model used to define information quality in this research.

Figure 2 construct of data quality



**2.3.5 Increased availability of Information technology increases the opportunities for SCIS**

Information technology (IT) is often used to facilitate information sharing across the supply chain members. Frequently used information technologies are Internet, intranet, software application packages, and decision support systems. These information sharing systems are used to provide or improve visibility in the supply chain by sharing, products, prices, locations, quantity, and demand patterns (Simatupang & Wright, 2002). According to (Chae et al. (2005), relevant IT capabilities for supply chain collaboration are Enterprise Resource Planning (ERP) systems, comanagement inventory (CMI) systems, electronic data interchange (EDI), electronic

Point-of-Sale (POS) scanners, electronic payment, barcoding, automatic replenishment of basic goods, automatic forecasting for fashion/seasonal goods, and advance ship notices (ASNs). According to Kembro et al. (2017), technology utilization is one of the barriers to efficiently implementing multi-tier supply chain information sharing. More specifically Kembro et al. (2017) found that implementation cost, linked IT-systems (common platforms, maturity of IT, standardized terminology, and standardized data exchange formats are the main IT barriers for multi-tier supply chain information sharing. However, systems and formats are available for multi-tier supply chain information sharing (Kembro et al., 2017). The digital technologies to communicate and interact with people and machines have increased heavily in recent times and affected supply chain and logistics services and possibilities. Examples are mobile devices, personal computers, self-driving cars, drones, advanced television units, wearable devices, smartphones, and smartwatches (Büyüközkan & Göçer, 2018) Other recent digital supply chains (DSC) innovation makes it possible to overcome the barriers of implementing multi-tier supply chain information sharing. Other DSC innovations include but are not limited to Augmented Reality (AR), Big Data (BD), Cloud Computing (CC), Robotics (R), Sensor Technology (ST), Omni Channel (OC), Internet of Things (IoT), Self-Driving Vehicles (SDV), Unmanned Aerial Vehicle (UAV), Nanotechnology (N) and 3D Printing (3DP) (Büyüközkan & Göçer, 2018).

According to Fawcett et al., (2009) commonly used IT investments to share information are internet interfaces, enterprise systems, and data capturing and analysis tools. Adamson et al., (2017) describe that a cloud-based framework enables all in a value chain to work together and share information. Cloud-based frameworks are a combination of in-house systems and cloud applications where cloud technologies can connect with the in-house systems of the supply chain (Adamson et al., 2017).

In addition to the increased availability due to technological advancement. The paradigm industry 4.0 is expected to further increase the availability information and the importance if SCIS.

Industry 4.0 is a connected network between the physical assets and smart computational capabilities which are self-aware, self-adaptable, self-optimizing, self-configurations, and self-regulating which increases flexibility, real-time coordination.

In the past chapter current information technologies that are used to enhance SCIS are provided. However, with the revolutionizing manufacturing sector more possibilities for SCIS are expected to occur. This part of the literature review provides an explanation of the new revolutionizing manufacturing sector which is often referred to as industry 4.0.

Industry 4.0, internationally called industry 4.0 or I4.0, was introduced during the Hannover fair in 2011. It was announced as the German strategic initiative to take a pioneering role in the revolutionizing manufacturing sector. Since then, industry 4.0 has been a hot topic in research. In addition, it now starts to become implemented more in practice. However, multiple different definitions of industry 4.0 are used in literature and often differ based on the context. In this part of the paper, the different definitions of industry 4.0 will be defined. Based on the multiple definitions, the definition of industry 4.0 which will be considered in this paper will be defined. Moreover, enablers of 4.0 will be provided in this part of the paper. Table 2 provides a table of multiple definitions of industry 4.0. Based on the collection of definitions it can be concluded that industry 4.0 is a connected network between the physical assets and smart computational capabilities which are self-aware, self-adaptable, self-optimizing, self-configurations, and self-regulating. Industry 4.0 has the benefits of highly flexible mass productions, real-time coordination, and optimization of value (Hofmann & Rüsçh, 2017) chains. According to Piccarozzi et al. (2018) Industry 4.0 enables firms to become more flexible, adaptable, and robust by having the permanent ability to cope with changing business environments by rapid rearrangement and reallocation of capacity, components, and capabilities (Ivanov et al., 2021) and by real-time coordination (Hofmann & Rüsçh, 2017).

However, also disadvantages of industry 4.0 have been found in past research. Industry 4.0 leads to reduced privacy, increased chance of cyber-attacks, information flows cannot be removed or hidden, and difficulties to keep intellectual properties. In addition, industry 4.0 restricts access to knowledge and understanding of actions, and industry 4.0 demands 24/7 running service (Oztemel & Gursev, 2020). In addition to the disadvantages (Majumdar et al., 2021a) found that lack of understanding and commitment of top management is the main barrier for the implementation of industry 4.0. Other barriers include, lack of trained staff, poor R&D towards industry 4.0, lack of information technology structure, fear of failure and the high implementation cost (Majumdar et al., 2021b)

Industry 4.0 is enabled by the accessibility and affordability of sensors, data storing and data acquisition systems, and computing power (Lee et al., 2015). According to Hermann et al. (2016) there are four key components of industry 4.0 which are, Internet of Things (IoT), Cyber-Physical Systems (CPS), and Smart Factories. IoT allows interaction and cooperation between components (Hermann et al., 2016). CPS cyber-physical systems (CPS) are defined as interconnected systems between physical assets and computational capabilities which exchange information and control actions independently and autonomously (Aceto et al., 2019). According to Kagermann et al. (2013) a smart factory is a factory with a decentralized



production System where humans, machines, and resources communicate as a social network.

Table 3 shows a list of in the past research described enablers of industry 4.0.

Table 3 Definitions of industry 4.0

Source	Definition
(Piccarozzi et al., 2018)	<p><i>“Industry 4.0 refers to the integration of Internet of Things technologies into industrial value creation enabling manufacturers to harness entirely digitized, connected, smart, and decentralized value chains able to deliver greater flexibility and robustness to firm competitiveness and enable them to build flexible and adaptable business structures [acquiring] the permanent ability for internal evolutionary developments in order to cope with a changing business environment as the result of a purposely formulated strategy implemented over time.”</i></p>
(Oztemel & Gursev, 2020a)	<p><i>“A methodology to generate a transformation from machine dominant manufacturing to digital manufacturing.”</i></p>
(Ivanov et al., 2021b)	<p><i>“Industry 4.0 is an integrity of technologies, organizational concepts and management principles underlying a cost-efficient, responsive, resilient, and sustainable network, data-driven and dynamically and structurally adaptable to changes in the demand and supply environment through rapid rearrangement and reallocation of its components and capabilities”</i></p>
(Schumacher et al., 2016)	<p>Industry 4.0 refers to <i>“recent technological advances where the internet and supporting technologies (e.g., embedded systems) serve as a backbone to integrate physical objects, human actors, intelligent machines, production lines and processes across organizational boundaries to form a new kind of intelligent, networked, and agile value chain.”</i></p>
(Qin et al., 2016)	<p><i>“Under Industry 4.0, manufacturing will consist of exchanged information and controlled machines and production units acting autonomously and intelligently in interoperable.”</i></p>
(Lasi et al., 2014)	<p><i>“I4.0 refers to a modular and efficient manufacturing systems and characterizes scenarios in which products control their own manufacturing process. This is supposed to realize the manufacturing of individual products in a batch size of one while maintaining the economic conditions of mass production.”</i></p>
(Hofmann & Rüsçh, 2017)	<p><i>“The Fourth Industrial Revolution can be best described as a shift in the manufacturing logic towards an increasingly decentralised, self-regulating approach of value creation, enabled by concepts and technologies such as CPS, IoT, IoS, cloud computing or additive manufacturing and smart factories, so as to help companies meet future production. requirements.”</i></p>

Table 4 Elements of industry 4.0

<i>Source</i>	<i>Elements of I4.0</i>
	<b>Information technology</b>
Alcácer and Cruz-Machado (2019)	(Industrial) Internet of things
	Internet of services (IoS)
	Cloud Computing / Cloud systems
	Cybersecurity
	Machine to Machine communication (M2M)
Oztemel and Gursev (2020)	Human-computer interaction
	Enterprise resource planning (ERP)
	Human-computer interaction
	Open source
	Blockchain
	<b>Information management</b>
Xu, Xu, and Li (2018)	Big Data
	Data mining
	<b>Production</b>
(Qin et al., 2016)	Augmented. Reality
	Artificial intelligence
(Aceto et al., 2019)	Additive Manufacturing
	Autonomous Robots
(Hofmann & Rüschi, 2017)	Cyber-Physical System (CPS)
	smart factory
	Simulation
	Virtual manufacturing
	Intelligent robotics
	Open source
	Sensors

## 2.5 Proposition and Conceptual framework, the types and factors that influence SCIS per tier in the supply chain

In this part of the paper, the Proposition and Conceptual framework is provided based on the existing research. The model includes summary of the found types of shared information which are identified during the literature research. These types are separated into strategic information and operational information. Moreover, it includes the found factors that limit information sharing. Based on the three categories identified in the existing literature. The aim of this model is to test if the types of information which are shared and requested are similar throughout the tiers of the supply chain. Also, of interest is to test if the factors that influence SCIS differ per tier of the supply chain and if there are different influencing factors between operational information and strategic information. In addition, this model predicts an interactive effect of Industry 4.0 on the factors that influence SCIS. The model is expected that Industry 4.0 effect the factors of SCIS because, Industry 4.0 enables more and wider interconnection between external partners (Wollschlaeger et al., 2017), and information becomes more available (J. Lee et al., 2015).

Figure 3 Theoretical model of SCIS

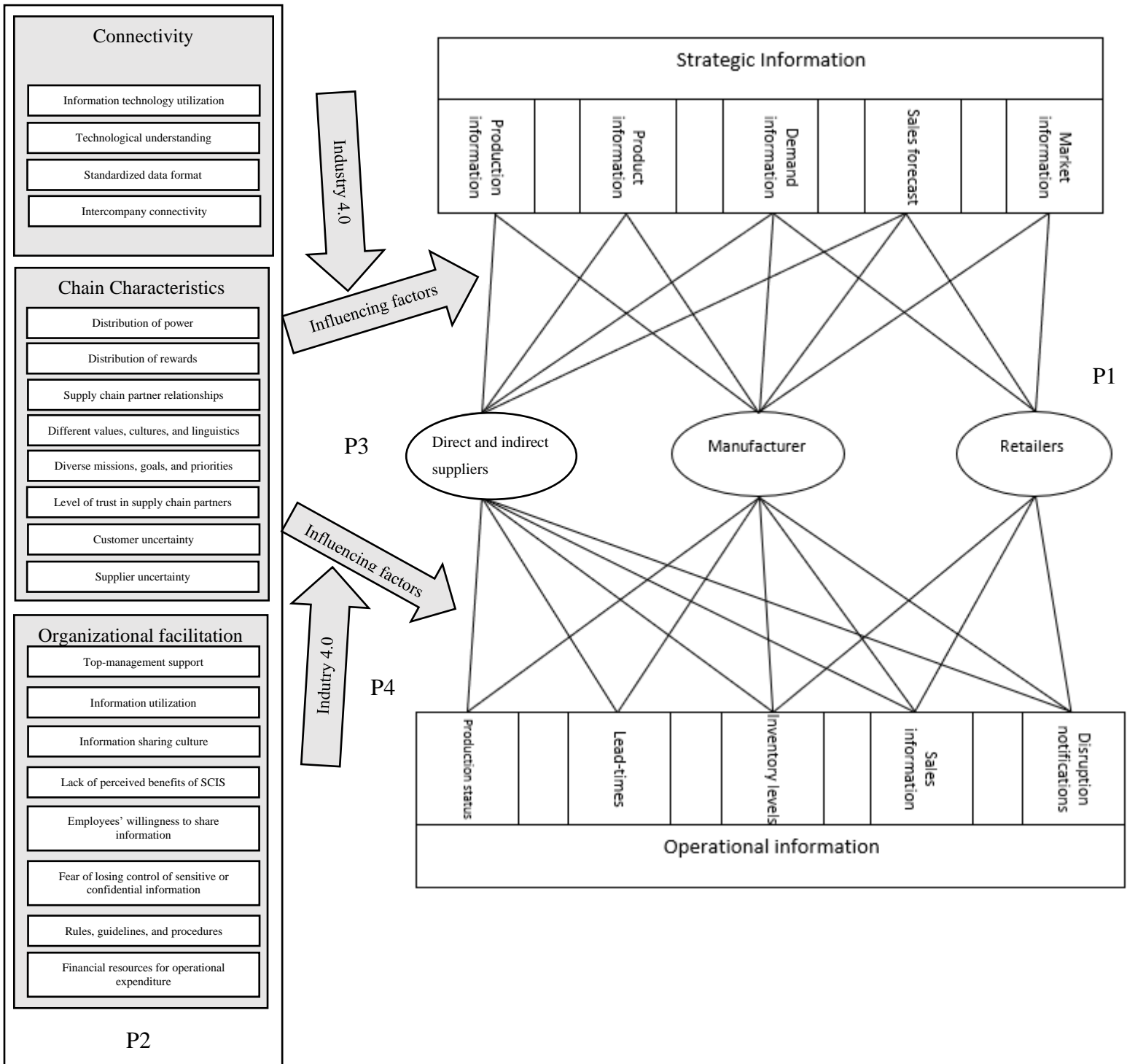


Figure 3 provides the conceptual framework including the types of supply chain information which were identified in the existing literature. In the conceptual framework three tiers of a supply chain are provided this is based on the simplified Keiretsu structure (Ellram & Cooper, 1990). A supply chain may have more tiers than provided in figure 3. If other supply chain tiers are included such as agents or importers the supply chain partners should define the needed types of information of the additional supply chain tier. However, this exceeds the aim of this paper as this paper uses the simplified keiretsu supply chain structure. The Keiretsu structure includes, (indirect)suppliers, manufacturer, and retailers. The types of information sharing can be divided into operational information and strategic information (Qi & Qingyu, 2010a). Operational information are the information flows that are based on short-time activities which are likely to fluctuate. Operational information is often used by lower-level employees to ensure the continuous flow of goods. According to Qi and Qingyu, (2010) operational information improves the performance of both upstream and downstream supply chain partners. Strategic information is information of long-time plans which are often decided on monthly, annual, or longer terms and are less likely to fluctuate. Strategic information is often used by Management to plan for longer periods. Qi and Qingyu, (2010) state that strategic information has the purpose to establish a long-term partnership and commitment among the supply chain partners. Strategic information involves the highest management levels of the organizations.

The Influencing factors of SCIS are divided into three factors namely connectivity, chain characteristics, and the willingness to share information as described in part 2.5 of this paper. The conceptual framework predicts which type of information is relevant to share with which supply chain partner. In addition, this model shows influencing factors of SCIS based on the existing literature.

**Proposition I: The of types of information shared differs per tier of the supply chain**

As previously mentioned, the types of SCIS identified in existing literature are divided into operational information and strategic information based on the definitions of (Qi & Qingyu, 2010). Table 1 shows the types of SCIS found in existing literature. However, existing literature does not differentiate between the tiers in the supply chain. Each tier of the supply provides different added value to the supply chain. Moreover, the tiers have different processes. Thus, is expected to benefit from different types of information. For example, it is expected that all tiers benefit from information sharing regarding distributions. Yet the indirect and direct suppliers are expected to no to little benefit from the sharing of sales information or market information. Therefore, proposition I tests if types of SCIS shared and received do differ per tier in the supply chain.

### **Proposition II: The factors influencing SCIS differ per tier of the supply chain**

Despite the benefits of SCIS, many supply chains do not use all benefits (Kimbrow et al., 2017). As mentioned in part 2.5, the factors that limit the level of SCIS can be divided into three groups, connectivity, chain characteristics, and organizational facilitation. However, in existing literature, no differentiation is made between the tiers of the supply chain. The following proposition expects that different tiers in the supply chain have different limiting factors.

### **Proposition III: The factors influencing SCIS differ between operational and strategic information**

This proposition predicts that the limiting factors to share information are different for sharing operational information and strategic information. This is expected as the characteristics of the information are different. Operational information is often fluctuating and is sent more frequently (Qi & Qingyu, 2010). The users of operational information are often lower levels employees while strategic information is often used by higher level managers (Qi & Qingyu, 2010). Qi and Qingyu (2010) describe that strategic information plans are often decided on monthly, annual, or longer terms and are less likely to fluctuate.

### **Proposition IV: Industry 4.0 will influence the factors that limit SCIS**

With the introduction of the Internet of Things and Cyber-Physical Systems, the industry is undergoing a significant change (Wollschlaeger et al., 2017). This industrial revolution is often referred to as Industry 4.0. With increased and more advanced technology, more and wider interconnection between external partners is possible (Wollschlaeger et al., 2017). Therefore, it is expected that Industry 4.0 will influence the factors that limit SCIS.

## **3. Research methodology; qualitative case study for theoretical model testing**

In this part of the paper, the methodology of the research will be explained. The methodology part consists of a description of the general design of the empirical approach, selection of the sample based on who, how, why. This is followed by a description of the characteristics of the sample. Moreover, the measurement instrument(s), data collection procedure, and data analysis procedure will be explained.

### **3.1 literature review on SCIS and industry 4.0**

Existing literature is studied to gain information and find theories regarding the topics, supply chain structure, supply chain information sharing, benefits and barriers of supply chain information sharing, the effect of information technology on information sharing, and to gain

knowledge and come to a clear description of industry 4.0. A structured literature review is conducted based on predefined keywords (see appendix I). In addition, snowballing of selected papers is used. The database Scopus and WebofScience are used to find relevant, peer-reviewed, academic articles and conference papers that are accessible as a student at the University of Twente.

For the first topic, supply chain structure is researched to define how a multi-tier supply chain can be structured. The second topic supply chain information sharing is researched to define the effects of supply chain information sharing on supply chain performance, for both topics, the articles were not filtered on year as not only recent research is relevant as older research on the structure of supply chains is still seen as valid. The articles are filtered on the areas of Engineering, and Business Management and Accounting. In addition, the results are filtered on articles and conference papers. Due to the innovation speed, changing possibilities, and opportunities in information technology research papers used to define information technology in supply chain information sharing have been limited to a maximum of five years. Only to define the definition of certain technologies older research might be used. The outcome of the search has manually been judged and selected based on the titles and abstracts of the papers.

### **3.2 Empirical data collection via semi-structured interviews in a single supply chain case.**

This research is conducted to identify the types of information shared in a supply chain and the factors that influence SCIS. In this research, a differentiation is made on all tiers of the supply chain. In addition, the interactive effect of the fourth industrial revolution on the factors of SCIS is of interest of the research. In order to get insight into this, a qualitative case research is found to be most appropriate. This as qualitative case research has its strength in producing novel theoretical insight from a specific case (Hoon, 2013). A case study research enables one to study a phenomenon in a real-life setting with an in-depth on a complex system in a few or single cases (Hoon, 2013). However other scholars argue that it lacks trustworthiness due to a small sample size and limited variability in the characteristics of the sample which reduces the generalizability (Rahman, 2016). According to Meyer, (2001), a lack of trustworthiness and generalizability can be avoided by a well-formed theoretical framework as this improves consistency, rigor, and trust in qualitative research. As this research has a deductive approach based on a well-formed theoretical framework, the researcher decided that a qualitative case study suits this research best as it is also able to capture feelings, opinions, and experiences which have to be considered to understand the willingness towards SCIS and industry 4.0.

The empirical data for this research will be received from semi-structured interviews. Interviews will be conducted with different levels from all tiers of the Keiretsu supply chain structure. So, interviews are conducted with, suppliers, a manufacturer (OEM), distributors, and retailers. These interviews will be conducted in one supply chain. The researcher contacted the manufacturer of the supply chain. Via the manufacturer, the contact details of suppliers, and retailers are received. Table 6 shows the information for the interviewed partners. In the semi-structured interviews, predefined standardized questions will be asked to the interviewees. A semi-structured interview is often used when the research wants to investigate a topic. The semi-structured interview suits this research best as the benefit of a semi-structured interview is that it enables the interview to be focused yet it gives the researcher the autonomy to explore relevant ideas which are brought up by the interviewee (Adeoye-Olatunde & Olenik, 2021). Which can further enhance understanding of SCIS and the effects of Industry 4.0 on SCIS.

The interview started with an introduction to the research and the topic to be investigated. Also, the purpose and the aim of the research will be explained in the opening part of the interview. Before asking the open-ended questions, the interviewer asked permission to record the interview and explain that the interviewee has the right to stop the interview or withdraw from the research at any time. The first set of questions are to gain information about the interviewee, the company they work for, and their view on the supply chain characteristics. In the second set of questions, the interviewer will ask general questions regarding SCIS. The third part of the interview is focused on the effects of connectivity on SCIS. In the fourth part of the interview, the questions are deeper into organizational facilitation and its effect on the factors which influence SCIS. The fifth part of the semi-structured interview focuses on the effect of industry 4.0 on the factors that limit SCIS. In the ending part of the interview, the interviewee is asked if they have any questions or remarks regarding the interview and if they are interested in the results of the study. Table 5 provides an overview of the key questions. After the interview is finalized and transcribed, the transcripts will be shared for verification which provides the interviewee the possibility to adjust the transcript if needed. The full interview protocol can be found in appendix II.

Operationalisation and explanations of propositions in the conceptual framework ensures clarity of the phenomenon measured. Appendix III provides an explanation of the elements of the theoretical framework

Table 5 Key questions of the interview protocol

<b>1. Introduction to research</b>	
<b>2. Information sharing</b>	
2.1	What is your view on sharing information with supply chain partners?
2.2	What do you consider as benefits of information sharing with supply chain partners and why?
2.3	What do you consider as disadvantages of information sharing with supply chain partners and why?
2.4	What information do you receive from your supply chain partners?
2.5	What information would like to receive?
2.6	What information do you share with your supply chain partners?
2.7	Which factors limit the amount of information you share with your supply chain partners?
2.8	Which factors limit the amount of information you receive from your supply chain partners?
<b>3. Connectivity</b>	
3.1	Which connectivity factors influence supply chain information sharing?
3.2	How does the level of information technology influence the amount of information shared?
<b>4. Organizational facilitation</b>	
4.1	What organizational characteristics influence the amount of information you share with supply chain partners?
4.2	To what extent do you feel the organizational characteristics of your supply chain partners limits them to share information with you?
<b>5. Supply chain characteristics</b>	
5.1	Could you tell me something about the characteristics of the supply chain? (follow-up question; how does this effect the level of information sharing?)
<b>6. Industry 4.0</b>	
6.1	How would a more self-regulating supply chain influence the flow of supply chain information?
<b>7. Summarizing question</b>	
7.1	To summarize the factors that influence information sharing, could you give a top 5 of factors that influence information sharing?
7.2	To conclude and summarize this interview could you give a top five of types of information which you find the most important to receive?



### 3.2.1 Population and sampling design

In this research paper, the aimed unit of analysis is supply chains that are structured according to the Keiretsu structure. The unit of observation is the supply chain of a Dutch Manufacturer of pharmaceuticals, health care products, and foods for pets. The company was founded in 1942 and is a family held. The firm has over 3000 products including flea and tick control, worm control, dental care, medicine, hygiene, treats, and foods. The company has in-house research and development as well as in-house production. With the aim to support the health and well-being of pets.

This case company is selected because this company has a wide variety of products in different sectors of pet care. Therefore, it has a variety of suppliers which means that the characteristics of suppliers are likely to differ. This increases the validity of the research. The author of this paper has no relationship with the case company other than for this research purpose. The author knew that this company is regularly interested in student assignments and research assignments. After explaining the research goal, the case company agreed to allow interviews with their supply chain partners. Table 6 below provides an overview of the respondent's profiles.

Table 6: Respondents profile

Anonymized Responded	Job title	Tier in supply chain	Interview Modality	Interview duration in min
R1	Supply Chain Planner	Manufacturer	Video call	52.36
R2	Operational purchaser	Manufacturer	Video call	48.41
R3	Strategic purchaser	Manufacturer	Video call	58.16
R4	Sales manager	Manufacturer	Video call	39.20
R5	Sales Manager	Indirect supplier	Phone Call	18:25
R6	Sales Employee	Supplier (packaging)	Video call	43.47
R7	Plant manager	Supplier (raw materials)	Video call	56.09
R8	Purchaser	Retail	Phone Call	23.06
R9	Supply chain manager	Distribution channel	Video call	41.53

### **3.3 Research reliability and validity**

According to Riege, (2003) to establish the reliability and validity in a qualitative case study, it is important to determine the stability and quality of the obtained data. To test the construct validity of the case study, Riege (2003) suggests using multiple sources of evidence. Therefore, in this research, the author tried to have at least two respondents per supply chain tier. To avoid an instinctive approach, a structured analysis approach is used. Before the interview predefined open questions were prepared in the interview protocol. The interview protocol can be found in appendix II. A structured interview approach has the aim to avoid satisficing or leading-the-witness questions (Gioia, Corley, & Hamilton, 2013). In addition, to increase construct validity, it is recommended to have confirmability from the interviewees. Thus, after the interview is finalized and transcribed. The transcripts will be shared for verification which provides the interviewee the opportunity to adjust the transcript if needed (Yin, 2003). Techniques suggested to increase external validity are, compare the case-study results to existing literature (Eisenhardt, 1989; Yin 2003). Therefore, similar research has been described in the past research chapter of this paper. Moreover, the results of the case study will be compared to the existing literature and will be discussed with the supervisors of this research which are experts in the field of purchasing, supply chain, and Industry 4.0. To ensure the reliability of a case study, proper documents of the followed procedures are necessary. Without documentation of the followed procedures, one is not able to replicate the case study (Yin, 2003). To ensure replicability of this research, the steps of the research will be described, including how the researcher found the case company, how contact details of the supply chain partners are received, and the interview protocol (see appendix III) are provided in the methodology section of this paper. The case study is conducted in a supply chain of a Dutch Manufacturer of animal pharmaceuticals, animal healthcare products, and foods for pets. In the supply Chain, most of the interviewed partners had long-term, five year or more, and good relationships. In the supply chain there is not a dominant player who can force changes. There is a rather equal dependence and power distribution. In this supply chain there is a mix of more “professional” bigger organizations and smaller organizations.

The qualitative data is analysed based on the Gioia Method (Gioia, Corley, & Hamilton, 2013). The Gioia Method is used to bring “qualitative rigor” to the construct and presentation of inductive research (Gioia, Corley, & Hamilton, 2013). The semi-structured interviews are transcribed. Based on the transcripts, the interview data is structured per category. The semi structured interview data is provided in appendix IV. Based on the semi structured information 1st-order analysis is done. This bundles the data into categories. To further reduce the

categories, the author processes similarities, and differences among the many categories. Based on the similarities and differences the second-order themes are defined. The second-order themes help to describe and explains the phenomena that is observed (Gioia, Corley, & Hamilton, 2013). Moreover, the related second-order themes are summarized into the aggregate dimensions. In addition to creating the rigorousness to the research, is also helps to visualize the research in a clear overview (Gioia, Corley, & Hamilton, 2013). The overview of the 1<sup>st</sup> order concepts to aggerate dimensions is provided in the results chapter of this paper.

## **4. Results**

In this chapter of the paper the results are presented based on the finding of the semi-structured interviews held with the case-companies supply chain. Firstly, the current situations and opinion towards information sharing in the researched supply chain is described. In the second part of this chapter the aggregate dimensions that influence SCIS are described. Chapter 4.3 provides the types of information shared and the difference in between the tiers. The different factors that limit and facilitate SCIS are provided in chapter 4.4. Chapter 4.5 describes the effect of I4.0 on information sharing. The reminding findings are provided into part 6 of chapter four. Finally, the synthesis of results is provided in part 4.7.

### **4.1 Current status of information sharing in the case tested supply chain**

In the studied supply chain, the overall opinion towards SCIS was positive and the interviewees were open to share information, *“We should share all information we can share. Because that would be improving the processes”* (R5 Sales manager case company). Also, their suppliers aim that sharing and receiving information is crucial as stated by the supplier of packaging. *“I think it is really vital to share a lot of information and honest information. Because, for us, it is really important to have a really good understanding of our customer and for us also in return, it is really helpful if our customers understand what our technical possibilities are.”* No harm is seen in sharing information with their supply chain partners, *“I am very open, I always think that it cannot harm, the shared information might make it a bit easier for the other partner”*. (R7 Plant manager of raw materials supplier). Not only the manufacturer and supplier believe in the importance of SCIS, also their customers. However, they seem to be more reluctant to share information. They use the information received to improve their performance as stated by the supply chain manager of the distribution channel, *“Information of suppliers is often used to prevent shortages, when this is received, we will try to find a solution for example by increasing our stock level in advance”* Also mentioned by the supply chain manager of the distribution

channel is that in the currently unsettled market, resource shortages and the Covid-19 Pandemic, information sharing is more important compared to a stable market. While they are using and requesting information, they are quite reluctant to share the available information. They are not as willing to share all types of information to other parties, *“it is very important to know which types of information it is. For example, Revenues of supplier is not something we will share with other parties such as retailers or other suppliers”* (R9 supply chain manager distribution channel). Despite the openness toward SCIS, the interviews indicate that there is very little structure in the information sharing, most information is shared via email or phone. Moreover, information does rarely flow directly to an indirect supply chain partner. *“Only information is shared between direct tiers of the supply chain”* (R6 Sales employee packaging supplier). As in example in the studied case, the customer shares the information of a change in product requirement with the manufacturer, however not directly to the tier one supplier. This slows down the speed of information which caused multiple issues due to the fact that information came too late. Stated by the sales manager from the packaging supplier *“I can understand that the manufacturer also takes this information from their customers. And if their customers are late to provide the given data, they of course can also just work with what they have at the moment. But I think this is the core problem about information sharing”* (R6 Sales manager Supplier packaging).

To conclude the current status of SCIS in the studied case, the supply chain partners are aware of the need of SCIS and are open to share the information with their supply chain partners. However, very little information is shared beyond their direct partners. In addition, information is mostly shared based on individual request. Rather than having information sharing structures.

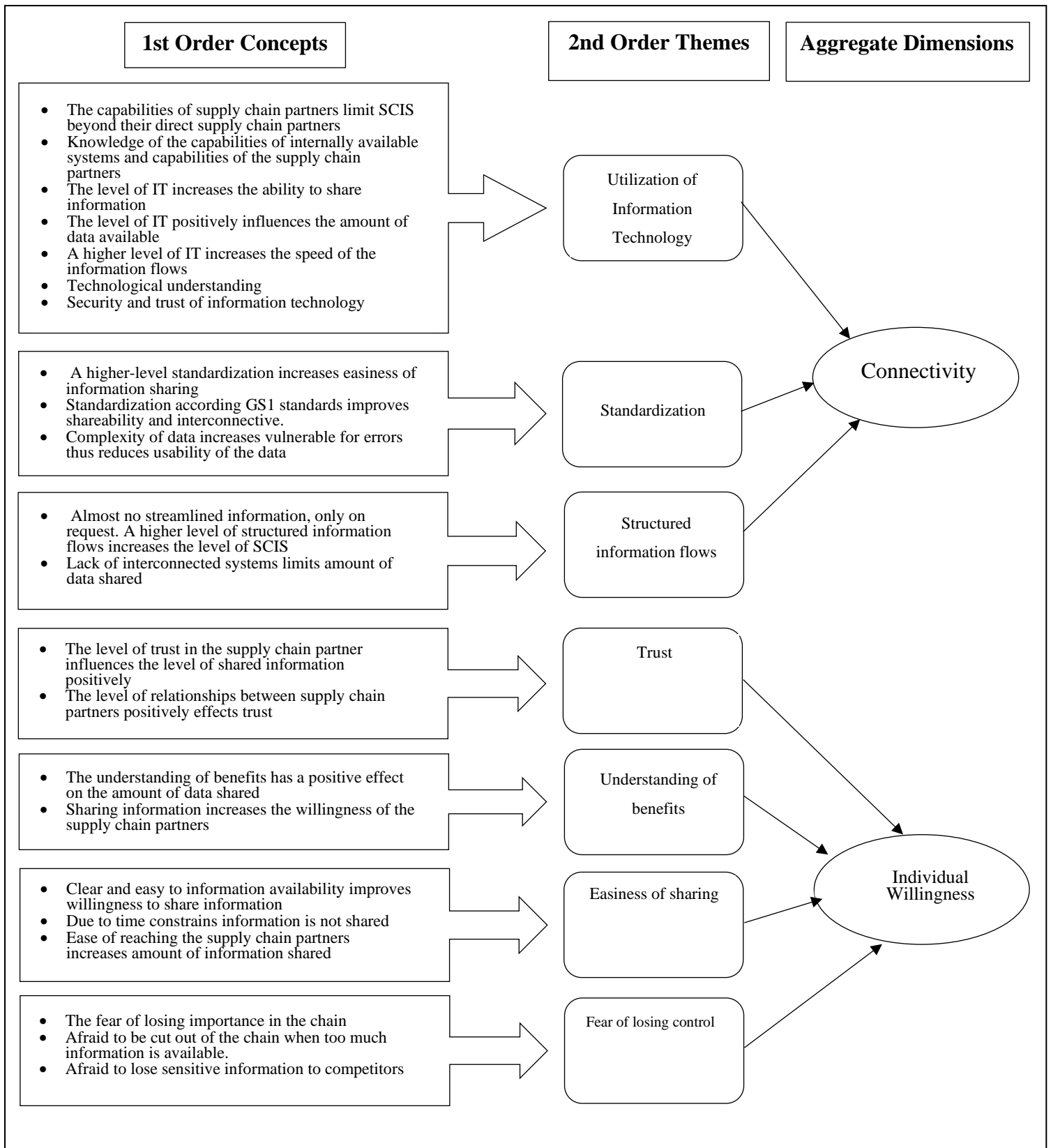
#### **4.2 Connectivity, willingness, supply chain characteristics, and organizational facilitation are the main influencers of the level of information shared with supply chain partners**

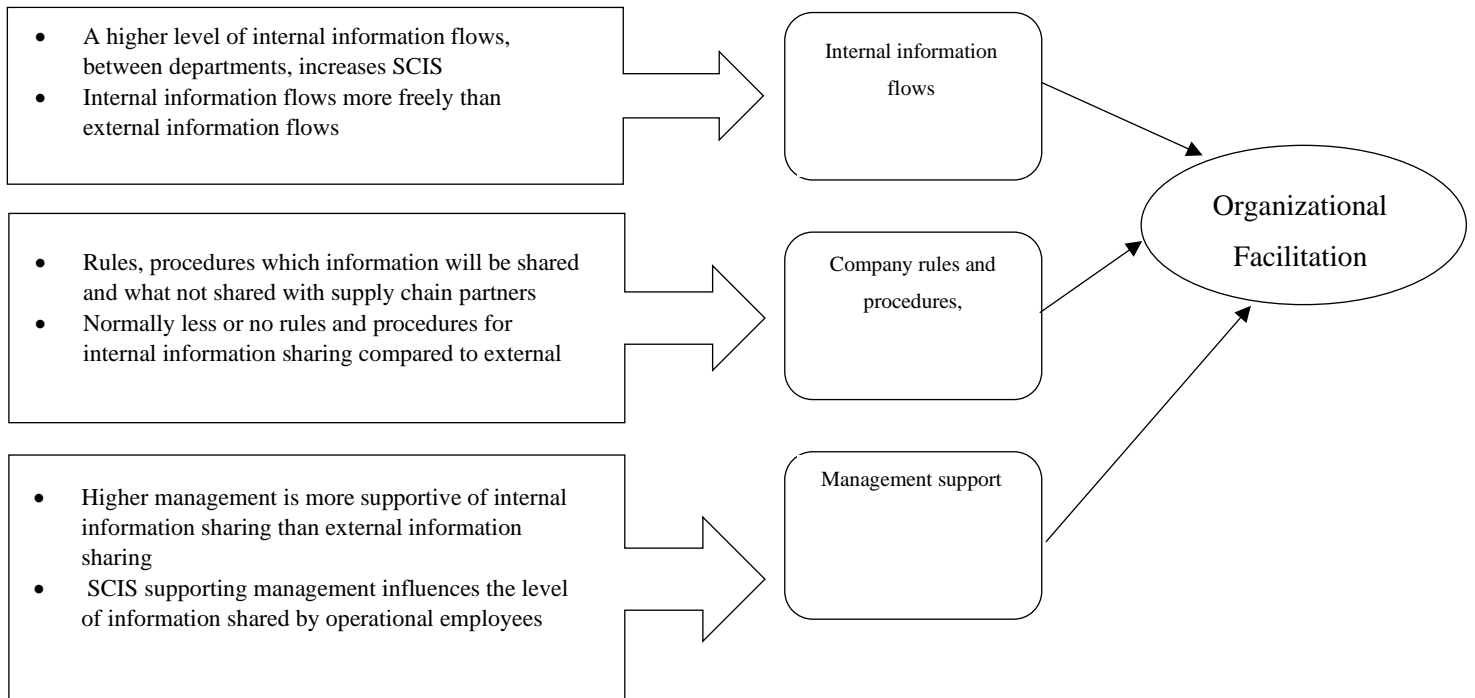
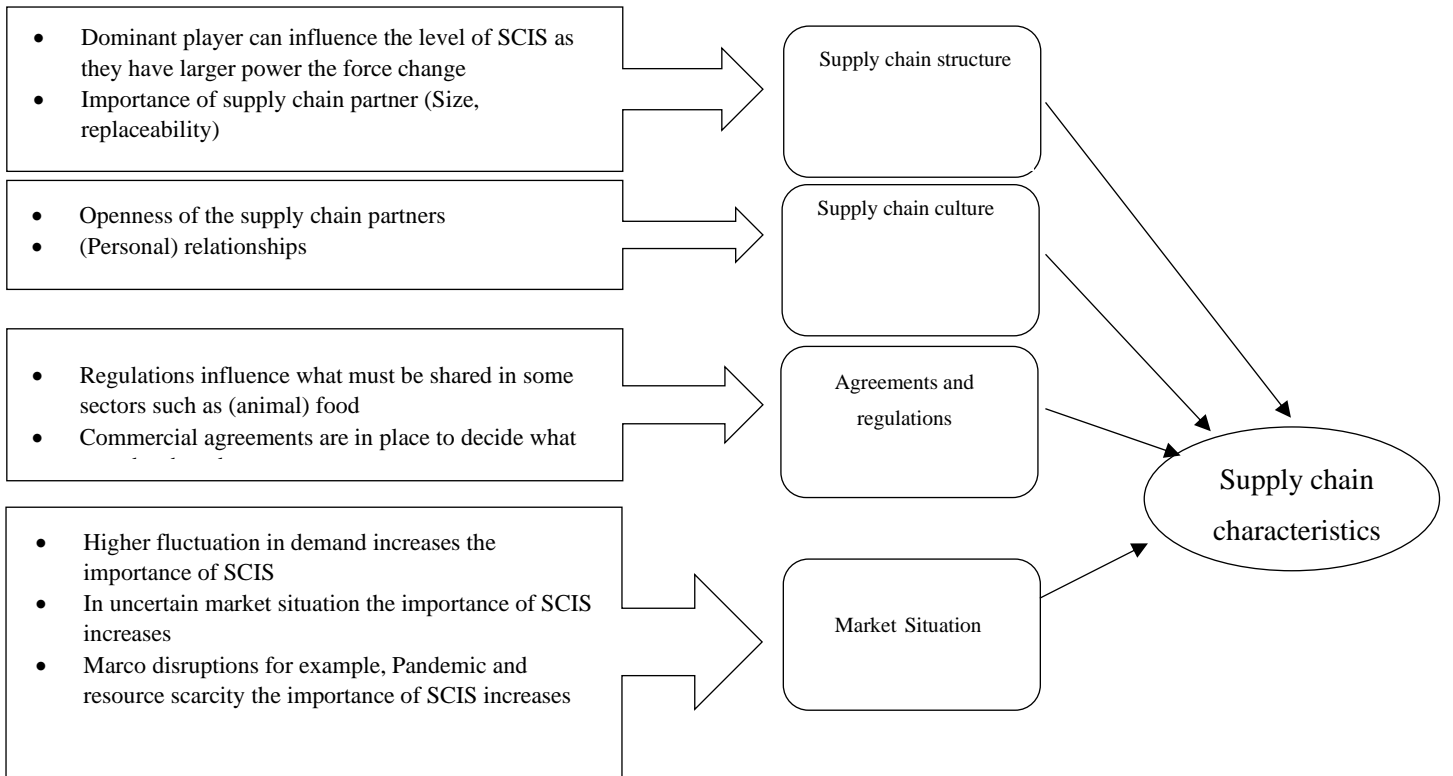
In this part of the chapter the limiting factors of SCIS are provided. With the transcript of the interviews, the collected data is structured according to the Gioia method. This method is used to bring “qualitative rigor” to the conduct and presentation of inductive research (Gioia, Corley, & Hamilton, 2013). Figure 4 below provides the 1<sup>st</sup> order concepts, 2 order themes and the aggregate Dimensions of factors that influence the level of SCIS. In appendix 3 is the table of semi-structured data received from the interviews.

Figure 4 shows the factors that influence SCIS can be divided into four aggregate dimensions namely Connectivity, willingness, supply chain characteristics, organizational facilitation. The Aggregate dimensions are further explained in part 4.2. Of these four

dimensions three were also found in the theoretical framework (figure 3 page 22). While willingness was not a dimensioned in the framework, it was mentioned as part of the organizational facilitation. In contradiction to the existing literature were willingness was seen as a sub-dimension, in the interviews the willingness of the employee and manager has a high impact on the level of information shared.

Figure 4 Order concepts, Themes and aggregate dimension that influence SCIS





#### **4.2.1 The connectivity of a supply chain influences SCIS.**

The first aggregate dimension connectivity consists of three 2<sup>nd</sup> order themes, namely information technology, standardization, and structured information flows. During the interviews it was stated by multiple interviewees that the information technology available influences SCIS. In the researched supply chain, the level of information technology does not offer multi-tier information sharing as stated by the sales manager of one of the suppliers. *“The systems of both large and smaller supply chain partners are not supporting information sharing, only information is shared between direct partners”*. Similar to the sales manager of a supplier, the internal sales manager has a somewhat similar view, he states, *“a lot of information is only shared when requested, we do not have linked systems”*. A different reason why information technology influences SCIS was mentioned by the supply chain manager of the distribution channel, *“having the right systems with the information available makes sharing of information easier”* (R9 supply chain manager of the distribution channel). This indicates that having the right systems improves SCIS by the availability and easiness to share information. The finding in the researched supply chain is similar to the research Khurana et al. (2011) which states that information technology increases the ease of sharing information. As mentioned in chapter 2.7 of the literature research, Kembro et al. (2017) found that, linked IT-systems (common platforms, standardized terminology, and standardized data exchange formats are the main barriers for multi-tier SCIS. Thus, similar to the results of the researched supply chain. As shown in figure 4 Standardization and structured information flows were often mentioned as a barrier to SCIS. In the interview with the supply chain manager, it was multiple times stated that standardization of data is a main driver to the shareability and usability of information. *“Retailers have their own data formats and conditions on how to receive and share data. With a more standardized format it would make it a lot easier for us to share information”* (R9 supply chain manager of distribution channel). Currently there is limited standardization in the studied supply chain. However, improvements are made because large retailers are now requesting to work according to the GS1 standards which does not only improve processes and reduces time for the separate chains. It improves the overall performance of the overall supply chain according to the supply chain managers of the distribution channel.

*“We have retailers who have an agreement where it is stated that the whole chain should be set-up according to the GS1 standards, this is not only in favour of their processes but also for the continuity of the entire supply chain”* (R9 supply chain manager of distribution channel).



In addition to the level of information technology and standardization, it was identified that the structured information flows effects SCIS. In the researched supply chain, it was mainly the lack of structured information flows and interconnected systems that limit the level of information sharing. Despite this many interviews mentioned that interconnected systems and more streamlined and structured information streams would improve the level of shared information. this is currently not used as stated in two quotes below for the sales manager (R5) and the operational buyer of the manufacturer (R2).

*“Most information is shared based on request, and we mostly receive this information but we do not have connected systems. I just call them when I want to have some information” (R4 Sales manager of the manufacturer)*

*And*

*The information we share is mostly by mail or phone, but mostly via mail so you can readback what you have received. (R2 Operational buyer manufacturer)*

To conclude the aggregate dimension connectivity, The three themes, utilization Information technology, standardization, and structured information flows were mostly mentioned during the interviews. The results of the interviews were quite like those of the literature review as shown in figure 3 Theoretical model of SCIS types. Based on the researched supply chain and the existing literature, it can be concluded that improved connectivity improves the availability, easiness, and speed of information sharing, thus connectivity has a positive effect on SCIS.

#### **4.2.2 Willingness to share information improves the amount and the quality of SCIS.**

The second aggregate dimension is willingness, during the interviews it was often mentioned that the willingness of the employee improves the amount and the quality of the information shared. Based on the interviews, four second order themes are included in the dimension willingness, namely trust, understanding of benefits, easiness, and fear of losing control of information.

Trust seems to be an important factor in what information they are willing to share. Trust seems to be more important for strategic information compared to operational information. Because operational information has a lower sensitivity level. Thus, fear of losing control of information is lower for operational information.

*“We have a really trustful relationship dating back to years prior when I was starting here at supplier x. And yeah, there is not really a lot that we would not talk honestly and directly about” (R6 Sales manager supplier of packaging)*

Also, the plant manager (R7) of the raw material supplier has a similar view on the importance of trust. He also mentioned trust is something which is built on a personal level rather than on organizational level.

*“If you trust someone with the information you are more likely to share the information. This is something build on mutually on personal characterises” (R7 Supplier of raw material plant manager)*

However, the most mentioned factor that influence the willingness to share information is the understanding of benefits. This 2<sup>nd</sup> order theme can be defined in to two main parts, one is the overall the understanding of the benefits information sharing. The second part of the parts the understanding of benefits is they understanding why the supply chain partner is interested in receiving certain information. The understanding of benefits information sharing increases the overall willingness to share information with supply chain partners. Because when partners understand that SCIS improves not only the performance for a certain tier but also benefits the overall supply chain, they seem to be more open towards providing information to their partners. Yet this also influences the willingness to invest toward SCIS improving technology and system and towards creating a culture were information flows freely. This seems to be more of interest in higher management functions who focus more on strategic information rather than lower levels employees who focus more on operational information.

*“My aim is to create a culture were information flows freely and easy trough the supply chain, were we are open to share the information needed”. (R1 Supply chain planner of the manufacturer)*

The second part of understanding the benefits is the understanding why the supply chain partner is interested in specific information. This was mentioned by many interviewees as an important factor when deciding to share or not share the information. The plant manager (R7) of the supplier of raw material even mentioned this as one of the three most important factor when deciding to share or not share the information with partners in the supply chain. However, this seems also of interest higher in the supply chain as stated by the sales manager the manufacturer

*“You should be limited in your information sharing so you only share the information, what is relevant for them” (R4 Sales manager of the manufacturer).*

In addition, the Supply chain manager mentioned that understanding the need of certain information helps to provide higher quality information because, then it is possible to only send the information needed and the provider of information can advise on what information might be best suitable.

*“We definitely look at who wants which information, it is easy to provide all the data but this is not useful for everyone. So, we try to understand what the aim of the information is. Sometimes this means we suggest providing other information that previously requested as this seems to be more useful” (R9 Supply chain manager of distribution channel)*

The internal sales director mentioned that larger and more professional organization have better understanding of the importance of information sharing. According to him, this increases the willingness to share information. In addition, the size of the supply chain partners is suggested to influence the importance of information sharing as this influences the effect on the over supply chain performance.

*“The more professional organizations with, with the bigger stores, they they will also know what is the importance of sharing this information? So, they are more willing to do so. The smaller organizations, sometimes they are they share less? But they do not influence our operation that much. So yeah, it is not that important to us either. (R3 Internal sales manufacturer)*

To conclude the understanding of benefits, based on the interviews it can be concluded that the overall understanding of benefits of SCIS influence the willingness to share information. When the benefits of SCIS are clear, people are more willing to share information. This is similar to Khurana et al. (2011) findings, who states that understanding of the benefits is one of the managerial barriers to SCIS. As limiting knowledge of the benefits of SCIS limits the investments towards creating as information sharing culture and willingness to invest in technology that enhances SCIS (Khurana et al., 2011). In addition to the overall understanding of the benefits of information sharing, the understanding of needs per supply chain partner was mentioned as one of the main factors on the deciding to share or not share the information. additionally, according to the interviews, understanding the needs of the supply chain partners also improves the quality of the shared information.

The third second order theme of willingness is the easiness sharing. This second order theme refers to the effort it requires to share information with supply chain partners. This dimension seems to be more of interest for operational information. Operational information is

shared more frequently compared to strategic information. Therefore, the ease to share information becomes more important. This second order theme is in close relation with the dimension connectivity due to the fact that most respondents mentioned that the level of information technology and systems has a large influence on the ease of sharing information.

*“I think a lot of it has to do with having the right systems and the internal information flows. When everyone has the right systems, information sharing becomes much easier”* (R9 supply chain manager of distribution channel)

#### **4.2.3 The dimension supply characteristics, exist of five 2<sup>nd</sup> order themes that influence SCIS.**

The third dimension that influences SCIS is supply chain characteristics. During the interviews five themes were often mentioned these themes are supply chain structure, supply chain culture, regulations, market situation, and commercial agreements. These five themes are bundled the arrogant dimensions supply chain characteristics. During the interviews, the themes supply chain culture and market situation were the most mentioned themes of supply chain characteristics.

Supply chain structure relates the distribution of power in the supply chain. This theme is similar to the dimension power structure, of Kembro et al. (2017) research on limiting factors on information sharing. This theme consists of the concept's dominant players and importance of supply chain partners. In some supply chains there are dominant players who can influence or force actions in a supply chain. If there is a dominant player in the supply chain, often this is the retailer or manufacturer. The dominant player in a supply chain can have both a positive and negative effect on the level SCIS. This depends on the attitude toward SCIS. If the dominant player has a positive attitude towards SCIS, this player can force smaller partners to share information.

*“Sometimes the power of large parties is exploited to force action in the chain, than we just have to do it.”* (R3 Strategic buyer of the manufacturer)

The other concept of supply chain structure which was mentioned in multiple interviews was the importance of supply chain partners, their size and replaceability. The size of the and the effect on the chain was often mentioned as an important factor if the request information or not request information. For smaller partners the effects on the chain are smaller, less information is requested as this will have a small effect on the operations of the other partners. An example mentioned by the sales manager of the manufacturer,

*“The more professional organizations with bigger stores, they they will also know what the importance of sharing information is. So, they are more willing to do so. And the smaller organizations, sometimes they share less. But yeah, they do not influence our operation that much. So yeah, it is not that important to us either.” (R5 Sales manager of the manufacturer)*

However, this mostly is only applicable for upstream supply chain partners. Small downstream partners such as suppliers can have very large impact on operations, mostly if they are difficult to replace. For this strategically important supplier the sales manager of the manufacturer mentioned it is important to share both strategic and operational information.

*“Strategic information is thought, important for your strategic important suppliers. So, if you have suppliers, which are not easy exchangeable. So, then I think you should take them with you in your journey towards your success for the future.” (R4 Internal sales manager)*

In addition to the structure of the supply chain, the culture in the supply chain was mentioned to influence SCIS. Here two concepts were frequently mentioned, namely openness of the supply chain partners, and relationships. The supply chain planner (R1) of the manufacturer mentioned that he aims to create a culture where information can flow through the chain and reach all partners involved.

*“My aim is to create a culture where information flows freely and easy through the supply chain, where we are open to share the information” (R1 supply chain planner of the manufacturer)*

The importance of creating a supply chain culture which is willing to share information was also found by Magnan and McCarter (2008) who state that creating a supply chain culture which is willing to share information is hardly replicable for competitors. Thus creates a more sustainable and non-imitable competitive advantage, rather than investing in IT solutions.

However, creating a culture which is willing to share information is suggested to be difficult as different company cultures and local cultures might be involved in the supply chain. The supply chain manager of the distribution channel states that in a supply chain with different cultures it is difficult to get similar openness from all parties involved,

*“There is a difference between cultures. Some cultures are more likely to share information while other cultures are more restricted” (R9 supply chain manager of distribution channel)*

To create a supply chain culture that is willing to share information the important factors in the supply chain culture are openness of the supply chain partners and the (personal) relationships with partners in the supply chain. During the interviews it was mentioned that relationship could

be between companies, for example if they have been working together for a long time. This was suggested to improve SCIS. However, relationships can also be on a personal level between the contact persons of the companies. Both seems to improve the level SCIS in the researched supply chain.

*“We have a really trustful relationship dating back to years prior when I was starting here at (supplier X). And yeah, there is not really a lot that we would not talk honestly and directly about” (R6 Sales employee of packaging supplier)*

*“If you trust a person with the information, it is mostly because of the personal characteristics of you have with that person” (plant manager, supplier raw materials)*

The sales manager of the manufacturer states that duration of the relationship influences trust. He states that if you are working together for a longer period, you trust each other more and they will be open towards sharing information. However, the shared information must still be of value otherwise the information will not be shared.

*“Longer contact means, you have more trust in each other, but there must be an added value to the information. I mean the information has to be useful” (R4 Sales manager of the manufacturer)*

So, it can be concluded that creating a supply chain culture which is willing to share information provides a sustainable and non-imitable competitive advantage. However, creating such culture is difficult to do due to differences in local and company cultures. In addition, the level of relationship influences the openness and willingness to share information. Relationship can be on personal level and on company level and both influence the experience they have together.

The third 2<sup>nd</sup> other theme of supply chain characteristics is rules and regulations. The researched supply chain operates in animal food and health care. In this sector there are rules, standards and regulations that means some information must be shared. This means rules, regulations, and standards influence the level of information sharing. In sectors which do not have these regulations, less information might be shared.

*“Rules, procedures and commercial agreements with supply chain partners and internal agreements are in place to decide which information can be shared. These rules are decided by higher management” (R9 supply chain manager distribution channel)*

The interviews were conducted during the Covid-19 pandemic and international resource shortages on for examples raw materials, transportation, and human resources. This might be a reason why the market situation was mentioned in almost all interviews.

*“Sharing information is more important in uncertain situations for example now with covid, transport and product scarcity” (R3 Internal strategic buyer)*

In addition, the supply chain manager of the distribution channel mentioned that they find it important that partners the supply chain share the effect of distributions such as the Covid-19 pandemic, raw materials shortage and the Sues canal blockage. This unsettled market led to extra information request from their supply chain partners.

*“When we noticed the market was unsettled, we tried to get more information from our suppliers, we created a tool in our system that registers when products are not received. Then the system sends an automatic mail requesting why it is not delivered and when we can receive it.” (R9 Supply chain manager distribution channel)*

To conclude the aggregate dimensions supply chain characteristics. The most mentioned second other themes are supply chain culture and market situations. Supply chain structure and agreements and regulations were mentioned less but still mentioned by multiple interviewees in of different parts of the supply chain. Thus, they also seem to influence the level of information shared.

#### **4.2.4 Organizational facilitation, the internal rules and procedures influences SCICS**

Based on the results of the interviews the fourth and final aggregate dimension identified is organizational facilitation. This aggregate dimension refers to the internal aspect of the individual company. Organizational facilitation can be divided into three separated second order themes, namely internal information flows, company rules and procedures, and management support. Internal information flows, refers to how much information is shared between departments within the company. During the interviews it was mentioned that the information the purchasing department received from other departments in the company was forwarded to their suppliers. This means that the level of information shared internally has an effect on what is shared to external partners. This also holds for the sales department, who mentioned they forward information received from for example planning department or procurement. In interviews the example of potential out of stocks was mentioned, this was internally communicated to the sales managers who then shares this information with their

customers. However, not all internally shared information will be forwarded to external partners, as mentioned by the supply chain planner (R1) of the manufacturer, who stated, *“There are no restrictions for internal information sharing however they are less supportive about external information sharing”* (R1 Supply chain planner manufacturer).

In above provided quote, they refer to higher management which is suggested to have both a direct influence on SCIS but also indirectly via other second order themes. Higher management creates rules on what information can be shared to external partners. Thus, it can be concluded that organizations are still more reluctant to external information sharing compared to internal information sharing.

*“Intern we make decisions if we are going to share the information with partners, this is mostly based on the agreements we make with suppliers, these are agreements are made by the directors”* (R9 Supply chain manager distribution channel)

However, not all interviewees provided same results, the operational buyer of the manufacturer stated, *“Employees decides what should be shared and what not, this is not based on management decisions”*. The difference between both is that the supply chain managers of the distribution channel have a higher function in the company and she mentioned that she mostly worked with strategic information, while the operational buyer mainly works with operational information. During the interviews, it was clear that strategic information is more sensitive compared to operational information. Therefore, it is expected that for more sensitive strategic information, higher management has a higher influence compared to operational level which is less sensitive thus operational information is less influenced by management support and rules. In addition, the results and opinions of the strategic buyer and operational buyer of the manufacturer are rather similar. Both are open to sharing information and mentioned that for new suppliers being open towards them improves their openness toward information sharing from the beginning of the relationship. Based on this we can assume that the support of management and higher functions influences what information is shared by low level employees.

#### **4.3 Difference tiers use similar types of information**

This section analyses proposition I: different tiers in the supply chain share and receive different types of information. In the theoretical model the tiers of the supply chain are divided into (in)direct suppliers, manufactures, and retailers. In previous research on information sharing limited to no differentiation was made between the tiers.



### 4.3.1 Direct and indirect suppliers

For the supply chain tier direct and indirect suppliers, timely production information from the manufacturer such as product specification, quality expectation, and purpose were mentioned as most important types of information. In addition, they expect feedback from the customers on how to improve the supplied goods. Also, to provide the best possible price and service, the suppliers mentioned receiving the expected demand improves their performance. Based on demand expectation they can work as efficient as possible. An example was mentioned by the supplier of the packaging. If the expected demand is received rather than just the order, the manufacturer mentioned they are able to organize the resources more efficient when future demand is known. Sharing demand becomes more important if the buyer does not fully understand the process and cost structure of the supplier. When only an order is placed for a certain quantity, the supplier can only quote the price for that quantity. When demand is shared, the resources of the supplier can be used far more efficient based on the knowledge of the supplier. Agreements can be made to combine orders which often results in lower production cost as setup cost, and scrap of raw material reduces. In addition, from receiving information from their direct supply partner (manufacturer) they mentioned that information from the markets was often received too late. For example, when the end customer was planning a promotional event which for a short period of time increased the demand. Often this information was only forwarded to the first-tier supply chain partner. This means that information has to pass many firms before it finally reached the suppliers. During the interview, the sales manager of the supplier (R5) mentioned that this information was often received too late or is never received. This caused that the resources could not be planned efficiently thus leading to higher prices. Likewise, the market did often not communicate expected drops in demand which also caused reduced efficiency in their resource planning. Besides demand information, the packaging supplier mentioned that receiving product information such as were used, what are the purposes, and needs is very useful to be able to provide the best suited product by enabling specific solutions thus creating additional value or a lower price for the manufacturer.

*“Packaging manufacturers, really need to understand what the product is and what the customer is going for with this product. There are a lot of factors that influence what is important and what is the right choice of packaging to go for. So, it is really vital for us to be very closely in touch with our customers and also our suppliers to achieve the perfect product”*  
(R6 Sales employee of packaging supplier)

To conclude the most important information types, received and requested from the direct and indirect are sales forecast, changes in demand, and product information. Forecast and

changes in the demand are requested to improve efficiency of the resources. Product information is requested to advice the customer and to enabling specific solution ad additional value and or a lower price to the customers.

#### **4.3.2 Manufacturer**

In the researched supply chain, the manufacturer was the tier which received most information from both the upstream as downstream supply chain partners. The information that was found to be most important is the forecast of the retailers and disruption notification from both suppliers and retailers. Both were mentioned by the supply chain planner (R1) and the sales manager (R4). Based on the forecast the manufacturer is able to plan its resources the most efficient way possible. This becomes more important when resources are scarce. In addition to the forecast, the sales manager mentioned it is important to receive the promotional schedule or other activities that influence the demand. Information that they would like to receive but do not receive is the capacities of the supply chain partners such as warehouse capacity or available technology. This to enable better connections and faster supply. In the researched supply chain limited information was shared with indirect partners. Thus, the manufacturer has an important role to forward the information to their direct partners. Both upstream to their sales channels and market information to their suppliers. Also, disruption notification was mentioned by the sales manager. An example was when we are getting out of stock do a supply distribution, we can divide the existing stock over our customers, which minimises the disruption for the retailers and end customers.

*“If we receive a notification, we can then we can divide our existing stock over more customers than that could be an advantage of knowing it at forehand.” (R3 sales manager Manufacturer)*

To summarize the information flows and request of the manufacture, The information that was found to be most important is the forecast of the retailers, promotion plans, and disruption notification from both suppliers and retailers. Receiving forecast enables the manufacturer to improve the efficiency and planning of their resources. The importance of sharing forecast increases in uncertainty and resource scarcity

#### **4.3.3 Retailers**

The retailer is the tier that is closest to the end customer, therefore they are the first to receive the market signals. This information, as mentioned before, is crucial for the production efficiency for the manufacturer and supplier. Information that retailers found most important is, supply information, logistical measurements, standardization (barcodes labels), supply chain

disruptions, fluctuation in demand and supply, and market changes. Besides to the operational information, they mentioned that high end retailers are requesting more product and commercial information. This information is used to be able to inform and instruct customers. For the retailers this an added value the offer to the end customer.

#### **4.3.4 Conclusion proposition I**

To conclude proposition I, different tiers request and use similar Strategic information however the different tiers use the information for different purposes. So, no support is found for proposition I as the important types of information are similar to differ tiers in the supply chain. As shown in figure 5 on page 51, strategic information is mostly shared, between the retailers and the manufacturer. However, the direct and in direct supplier state that they do not receive enough demand information, sales information, and market information. This information should flow from the retailer via the manufacturer to the supplier, in the researched supply chain this information is not fully shared with the supply side. Overall, the operational information was shared less between the tiers but also requested less than expected from the theoretical model. The only requested information was lead times and disruption which causes changes in the agreed delivery date. Based on the interviews it can be concluded that all tiers find information related to the demand most important. This includes the forecast and changes in demand due to promotions or changes in the market. For all tiers, this information helps to improve the efficiency and resource allocation. In addition, all tiers mentioned that market and supply disruption as an important information flow. The notification of disruption is used by the tiers to inform the partners in the chain and to reduce the impact on the and customer. In the theoretical framework, it was not expected that suppliers were interested in market information. However, based on the interviews it can be concluded that supplier and indirect suppliers are interested in market information. Besides demand information, both the retailer side and supplier side request product information. Moreover, both sides use the information to provide additional services. For the retailer side this information is used to inform and instruct customers thus, providing additional services. Whereas for the supply side, this information is used to be able to provide additional services by enabling specific solutions thus creating additional value or a lower price for the manufacturer. In the researched supply chain, much less types of information are shared than expected based on the literature research. For strategic information this is less the case compared to operational information. It seems that less is information is requested as only direct and indirect supplier mentioned they not receive the information they needed. Proposition II will test what limits information sharing.

#### **4.4 Factors that limit information sharing does not differ between the tiers but differs between operational information sharing and strategic information sharing.**

Despite the benefits of SCIS, many supply chains do not use all benefits (Kimbrow et al., 2017). Based on the interviews, it seems that the researched supply chain is open to share information, all interviews mentioned they are open to share most information. This is also shown in figure 5. Most of the requested information is shared. However, in the researched supply chain there are many types of information which are not shared nor requested moreover, there are also requested but not received information flows. However, in existing literature, no differentiation is made between the tiers of the supply chain. Proposition II expects that different tiers in the supply have different limiting factors.

Proposition II tests what limits these information flows. Figure 5 on page 51 shows there is a difference between in operational and strategic information. moreover, Figure 5 on page 51 indicates that most of the strategic information is requested, not all is received, but for operational information is less requested. Proposition III test if different factors influence the strategic information sharing compared to operational information sharing. As mentioned, the factors that limit the level of SCIS can be divided into four groups, connectivity, willingness, supply chain characteristics, and organizational facilitation.

##### **4.4.1 Direct and indirect Supplier,**

The main factors that limit information sharing for the supplier side are the trust in the supply chain partners, understanding of the benefits, understanding importance of information sharing, and the availability of information. Moreover, capabilities of the IT systems increase the amount of information shared as increases the amount of information collected and increases the ease to share, receive and information. multiple suppliers mentioned that time constrains is an influence why they are not much information sharing information. This seems to be the more the case for operational information as less information is requested.

*“Other partners are willing to share information however it is not done because, time constrains (R6 sales manager packaging supplier).”*

*“The easiness to reach someone or provide the information influence the amount of information shared.” (R7 Plant manager raw material supplier)*

The packaging supplier states that an inter-company connected systems would save time and thus increases the speed of information flows. which is suggested to be more important for operational information compared to strategic information. This due to the fact that operational

information is shared more often and need to be received timely. While this is mostly not the case for strategic information as this is only shared a few times a year.

*“Due to time constrains information is not shared. An inter-company connected system should and save time for the users and increase the speed of the information flow” (R6 Sales employee of packaging supplier)*

Another factor that was often mentioned was understanding of the benefits, this also shows in the figure 5 on page 51 there are lot of information types which are not requested, this also indicates that suppliers in the researched supply chain lack understanding of the benefits of SCIS which limits the level of SCIS.

The fear of losing importance in the chain was also mentioned as factor why not all information is shared. This was mentioned by the supplier of raw material who stated that if he shares too much information, he might loss his importance in the supply chain and might be cut out. This has more effect on strategic information rather than operational information as strategic is often more sensitive information compared to operational information.

*“The right to exist in the chain is something you want to keep this is where people are always scared of. When you share too much information, for example were it comes from, then the can directly go to your suppliers.” (R7 Plant manager raw material supplier)*

#### **4.4.2 Manufacturer**

In the researched supply chain, all employees for the manufacturer states that they are open to share information and willing to sharing as much as possible. As shown in figure 5 it can be concluded that for the manufacturer most strategic information that is requested is also received from both retailers and supplier side. Thus, in the researched supply chain, willingness does not seem to be the factor that limits the flow of strategic information towards the manufacturer. Despite the openness, figure 5 shows that very limited operational information is requested by the manufacturer. Based on the interviews, the main factors that limit information sharing for the manufacturer tier are, lack of understanding of benefits of SCIS, poor relationship with partners, security of connected, lack of (interconnected) Information technology to share in an easy manner, no streamlined information flows only on request, and afraid to lose sensitive information to competitors. An interesting statement was made by the Supply chain manager distribution channel, in this case there is not a real dominant player in the supply, however the manufacturer seems to have most influence on process, but not as much to be able to force changes in processes such as information sharing.

#### **4.4.3 Retailers,**

The interviewed Supply chain manager distribution channel was highly focused on standardization of information. The lack of standardization and thus the time it takes to share information. was for the supply chain manager the main reason why not all operational information was shared. Willingness was not directly an influencing factor, however internal rules procedures and commercial agreements with supply chain partners are in place this limits the level of SCIS. Moreover, these rules are often decided by higher management thus, support of higher management has effect on the amount of information which is shared. Based on the interviews, management support and rules and procedures have more influence on strategic information as this is often more sensitive and have a higher change of mistreatment of information. A mentioned example was selling the information to competitors.

#### **4.4.4 Conclusion proposition II and proposition II**

**To conclude proposition II**, which test if factors that limit SCIS differ per tier of the supply chain, can be concluded that most factors are similar for all tiers. The factors that are similar are summarised into the four aggerate dimensions connectivity, willingness, supply chain characterises and organisational facilitations. There are some factors that are only valid for a certain tier due to the position in the supply chain. However, in overall it can be stated that the factors that limit SCIS are similar for all tiers. Thus, no support is found for proposition II.

**Proposition III** tests if there is a difference between strategic and operational information sharing. Based on the conducted interviews, it can be concluded that different factors influence if operational information is shared compared to strategic information. Operational information, the utilization of information technology, standardization, structured information flows, and easiness of sharing are the main factors which limits sharing operational information. This since operational information should be shared on a more frequent level. Thus, it should be as easy as possible and should take a little time as possible. While strategic information is shared less frequent these factors are less relevant. Trust, Fear of losing control of information, Supply chain culture, Agreements and regulations, and Management support are factors that have more influence on strategic information rather than operational information, due to the fact that strategic information is seen as more sensitive information. So, proposition III is supported as there is a difference in factors that influence strategic and operational information sharing.

#### **4.5 Industry 4.0 is expected to effect on operational information sharing and limited effect on strategic information sharing.**

Proposition IV tests the effect of industry 4.0 of SCIS. The interviews understand the benefits of I4.0 as it can increase, ease of sharing, the speed and frequency of sharing information. As mentioned in proposition III this is more important for operational information sharing compared to strategic information sharing. similar results came from the researched supply chain

*I4.0 can increase the frequency information is shared (R7 plant manager supplier raw materials)*

&

*I think for the operational that it really could help us and be more efficient. But for strategic I think it should be done by people; I think that we should rely on that on artificial intelligence. (R3 Strategic buyer manufacturer)*

However, in the researched supply chain the interviews were quite reluctant to I4.0 information sharing. The supply chain managers were afraid to lose the flexibility and creativity of the human brain. In addition, the internal supply chain planner (R1) mentioned that because of the financial investments, it increases dependency with partners and reduces the flexibility to switch between partners and thus reduces healthy competition. Which may cause increase in price after the financial investment is made.

*“I4.0 increases strength of supplier risk of price increases after financial investment is made” (R1 internal supply chain planner)*

**To conclude proposition IV**, industry 4.0 is expected to have an effect on the factors that limit SCIS. Furthermore, it is expected to have a larger effect on sharing operational information compared to strategic information. However, industry 4.0 increases the dependency of partners which causes so reluctantly to implement I4.0 technologies. So, proposition IV is supported, as industry 4.0 is expected to have an effect on the factors that limit SCIS.

#### **4.6 Conclusion of propositions**

The conclusion of the four tested propositions can be found in table 7 below. For two of the four proposition no support was found. No evidence was found that supports those different tiers use different types of information. Moreover, no evidence was found that the arrogate factors that limit and facilitate SICS differ per tier in the supply chain. For proposition III and

IV supporting evidence in found. Based on the interviews it can be concluded that different factors effect strategic information sharing compared to operational information sharing. Moreover, evidence in the case study was found to support that industry 4.0 has an effect on SCIS. The effect is greater on operational information sharing compared to strategic information sharing.

Table 7 Summary of propositions

propositions	Support / No support	Reasoning
I	No support found	No difference in types of information used was found between the different tiers
II	No support found	No difference was found between the arrogate factors for different tiers
III	Supported	A difference is found in the factors that influence strategic comparted to operational information
IV	Supported	Support is found industry 4.0 has an effect on SCIS. The effect is greater on operational information sharing compared to strategic information sharing

#### 4.7 Remaining findings, Lack of structured information flows, limits SCIS while Market uncertainty increases SCIS

Despite the openness towards SCIS it is not widely implemented in the researched supply chain. In the researched supply chain, the lack of a structured information flows, standardization, and the utilization of information technology increased the needed effort to share information. Therefore, a lot of information is not utilized or requested. This is similar to the findings of Khurana et al. (2011) who state that information technology increases the ease of sharing information. In the researched supply chain, it seems that lack of knowledge and top management commitment limits the IT investments.

Secondly, the researched supply chain lacks structured information flows, all information is requested on an individual level rather than automized. Moreover, al information was only received from there direct partners. This often-caused interruptions in the information causing that information did not reach al partners in time or did not even reach the partner. A mentioned example was the promotion forecast of the retailer, in the researched supply chain this information had to from the retailer to all tiers to end up at the raw material suppliers. Who mentioned during the interviews that not all information came in time or was not received. Similar issues were also upstream, where retailers were not informed of shortage in resources



causing out of stocks which they were not early informed of while the issue was already clear to lower tiers in the chain.

*“When there are shortages and we only know this at the moment we want to buy the product, we not get this information from our suppliers” (R9 supply chain manager distribution).*

Thus, in a supply in a supply without multi-tier information sharing, the manufacturer has a very important role in the information flow through the chain as it functions as middleman. Different department receive different information, which is beneficial for other partners in the chain, thus internal information sharing is very important.

The interviews were conducted during the Covid-19 pandemic, which means the market was unsettled and uncertain, causing resource scarcity in transport, employees, and materials. And remaining finding was that during this uncertain time, more information was requested and all chains found in important to receive information as soon as possible to ensure timely delivery as leadtime and transportation time were much longer than before the Covid-19 pandemic. Thus, it can be concluded that uncertainty in the market influences the amount of information requested.

#### **4.8 Synthesis of results and revised model of SCIS**

Based on the systematic literature review, the SCIS model was drafted. This model was validated with a case study in the supply chain of a Dutch Manufacturer of pharmaceuticals, health care products, and foods for pets. In the researched supply chain not all types of information are shared nor requested, however the scope of the research was not to find if all types of information are shared. The scope was to validate the factors that limit information sharing and to validate the expected effect of industry 4.0 on the factors that influence SCIS. Figure 5 shows the revised model based on the factors that limit SCIS in the researched supply chain. Although the researched supply chain was very open towards sharing information, the factor connectivity was limiting SCIS due to poor utilization of information technology, limited to no standardization, intercompany connected systems, and no structured information flows. Structured information flows were not included in the theoretical model of SCIS. Yet, in the researched supply chain it was identified that the lack of structured information flows limits the information that is requested and shared through the supply chain. Thus, the connectivity seems to have a direct effect on SCIS and a moderating effect on the ease of sharing information.

In the theoretical model of SCIS, individual willingness was not included as a separate factor that influences SCIS. Individual willingness was included in the factor organizational facilitation. However, in the researched supply chain the interviewees mentioned that the individual willingness of the employee has a direct effect on SCIS. It was often mentioned that the employee decides if information will be forwarded or not. The individual willingness of the employee has more effect when there are few organizational rules, guidelines, and procedures. Therefore, in the revised model, individual willingness is included as a separate influencing factor on SCIS. Individual willingness consists of the 2<sup>nd</sup> order themes, trust, understanding of benefits, Easiness of sharing, and fear of losing control of information. The researched supply chain the interviewed employees were very open to share information as they trusted their partners, some suppliers mentioned the fear of losing control of information as a limiting factor despite this, the researched supply chain was open to SCIS. However, the willingness to share information was reduced due to the needed effort to share information as a result of poor connectivity. Thus, the connectivity seems to have a direct effect on SCIS and a moderating effect on the ease of sharing information.

The factor supply chain characteristics that influence SCIS were rather similar in the researched supply chain and in the theoretical framework. Even though there was no significant dominant player in the supply chain, interviewees mentioned that a dominant player has the power to influence processes such as SCIS. Furthermore, in the researched supply chain the focus was on (long-term) relationships with partners this favoured SCIS in the researched supply chain. Moreover, in the researched supply chain, there was a high level of trust in their partners which also favoured information sharing. During the case study, there was quite some uncertainty, not only customer uncertainty or supplier uncertainty, which was in in the theoretical model, also the wider macro uncertainty due to the Covid-19 pandemic and resource shortages caused increased the amount and frequency of information which is requested and used by the supply chain partners. Thus, Macro uncertainty is added to the framework. Besides Macro uncertainty, agreements and regulations are also added to the framework, due to the nature of the researched supply chain, animal food and Dutch Manufacturer of pharmaceuticals, health care products, and foods for pets meant some forms of information sharing was regulated by law. Such as product quality and trackability of suppliers and materials.

The factor organizational facilitation was both in the theoretical framework as in the results of the researched supply chain, The subfactor financial resources for operational expenditure was not mentioned in any of the interviews. Therefore, financial resources for operational expenditure were reconsidered and it was concluded that financial resources for

operational expenditure on its own is not a factor that influences SCIS. Thus, is not included in the revised framework. It is likely that is has an indirect effect on SCIS as it might increases investments in the factor connectivity. Yet it is not a direct factor for SCIS. For future research, it would be interesting to test if financial resources for operational expenditure indeed influence the investments into connectivity. Yet this is outside the scope of this research.

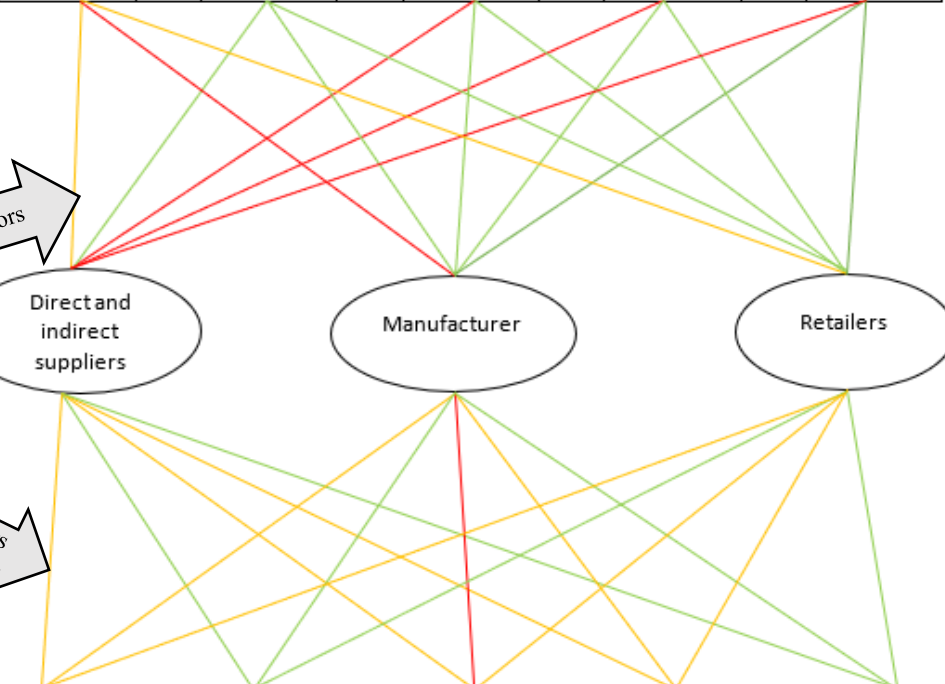
Based on the theoretical framework, it was expected that there is an interactive effect of Industry 4.0 on the factors that influence SCIS. Similar results were in the researched supply chain. The interviewees expected that overall industry 4.0 has a positive effect on SCIS. However, based on the researched supply chain it was expected that has a larger effect on sharing operational information compared to strategic information. The interviewees mentioned that industry 4.0 would mostly improve the quantity and the speed of information thus, would have more effect on operational information as these benefits from increased availability and improved speed of sharing.

Figure 5 Revised framework

Legend of Lines in SCIS model

	Requested Shared
	Not requested but shared
	Requested but not shared
	Not requested not shared

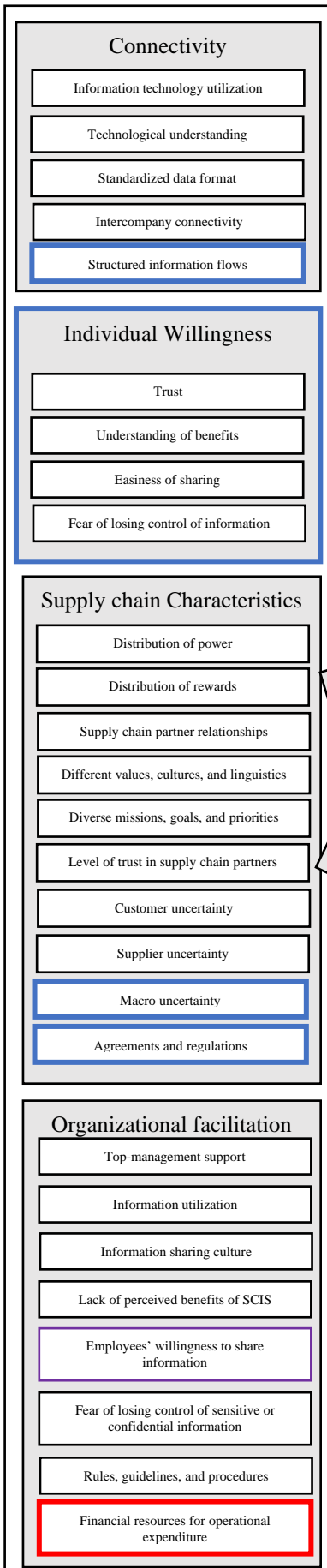
Strategic Information							
Production information		Product information		Demand information		Sales forecast	Market information



Production status		Lead-times		Inventory levels		Sales information	Disruption notifications
Operational information							

Legend of Revised Factors

	Added to theoretical model based on case study
	Included as separate arrogant dimension
	Removed from theoretical model based on case study
	Not revised



Industry 4.0

Influencing factors

Influencing factors

Industry 4.0

## **5. Discussion and conclusion**

In this part of the paper the key findings from the previous sections of the research are summarized. As well as an explanation of the limitations of this research. In addition, the theoretical contribution and actionable practical implications are provided in this section of the paper.

### **5.1 Key Findings, SCIS improves supply chain performance but connectivity, individual willingness, supply chain characteristics, and organizational facilitation limits SCIS**

This case study contributes to the current research in information sharing as this research is conducted in a complete supply chain rather than just the procurement or on the sales side. The research provides a tested theoretical framework with the types and factors that influences information sharing in a supply chain.

The paper aims to fill this gap of generalization on the factors that influence information sharing between supply chain tiers. This research found that SCIS improves supply chain performance. This finding is similar to the research of Huo et al., (2014) and Kim and Chai, (2017), The importance of SCIS increases in vulnerable and unpredictable supply chains. In the researched supply chain, more information was shared and requested in recent years, this was an effect of the uncertain market situation because of Covid-19 and resource scarcity. This paper did not find evidence to assume that different tiers in the supply chain use different types of information. However, the different tiers use the information for different purposes. For all tiers, information regarding changes in demand or supply is seen as most important.

Even though in the researched supply chain the interviewees were open towards sharing information, there was only limited information sharing throughout the supply chain. A key finding of this research is that the factors that influence can be divided into four arrogant factors that influence SICS, these four arrogant factors are 1) Connectivity (2) Individual willingness (3) Supply chain characteristics (4) Organizational facilitation. These factors should be taken into consideration when improving supply chain information sharing. In the theoretical framework, three types of factors were found to influence SCIS. These are connectivity, supply chain characteristics, and organization facilitation. The theoretical framework was mostly constructed based on the research of Kembro et al. (2017) who grouped 22 factors into six categories, namely, information utilization, technology utilization, power structures, culture, business process, and legal. While Fawcett et al., (2007) state that lack of connectivity, asymmetric power in a supply chain, and willingness are the main factors that limits information sharing. In addition to Kembro et al. (2017) and Fawcett et al., (2007), Khurana et al. (2011),

states that six main factors influence information sharing. These six main factors are, managerial, organizational, technological, individual, financial, social, and cultural. Based on past research, it was concluded that different researchers divide the influencing factors differently. Some researchers have more groups while others combine more factors into one group. However, most factors are relatively similar. Based on the past research the three categories Connectivity, Chain characteristics, and Organizational facilitation summarizes all factors of past research. In contradiction to past research, where individual willingness was included as a subcategory of organizational facilitation, this research found evidence that individual willingness is an arrogate dimension of SCIS rather than a subcategory. Due to the fact that in the researched supply chain the interviewees mentioned that the individual willingness of the employee has a direct effect on SCIS. It was often mentioned that the employee decides if information will be forwarded or not. The level of trust in the supply chain partner, the understanding of the benefits of SCIS, the ease of reaching the supply chain partners, and the fear of losing control of the information are the 2<sup>nd</sup> order themes found to influence the willingness of the individuals to share information. Therefore, this paper includes individual willingness as a main arrogate dimension in contradiction to Kembro et al. (2017) and Fawcett et al., (2007) research.

Kembro et al. (2017), state that the lack of information technology utilization is a barrier towards information sharing. In the researched supply chain, a lack of interconnected system and the lack of structured information streams were found to be limiting the amount and frequency of information shared throughout the supply chain. Moreover, the lack of interconnected systems was found to be a barrier towards multi-tier supply chain sharing. Despite the importance of information technology utilization, it was found that information technology utilization is relatively easy to replicate by competitors while, creating a supply chain culture that is willing to share information is hardly replicable for competitors thus creating a more sustainable and non-imitable competitive advantage (Fawcett et al., 2009). The researched supply chain was found to be very open towards information sharing. However due to time constraints and the needed effort to share and utilize information they only requested and shared limited amount of information. Thus, the researched supply chain is expected to benefit more from investments in information technology while a more closed supply chain would barely benefit from investments in information technology. Moreover, the interest of employees to share information is lower when they do not enjoy freedom due to limited empowerment (Khurana et al., 2011). Similar was found in the researched supply chain, where the lower-level employees of the manufacturer mentioned they were able to decide what they

are willing to share and had limited organizational rules on what they should or should not share. The opinion towards SCIS was more positive compared to the interviewee of the distribution channel who stated that management decided what they are allowed to share. It was expected that different tiers in the supply had different factors that limits and facilities SCIS. However, no supporting evidence was found. There were different second order themes and different first order concepts but in the Aggregate Dimensions, no difference was found between the tiers. Suggested for further research is to research to what extent each second order theme influences the Aggregate Dimensions. This paper found that different factors influence operational information sharing compared to strategic information sharing. Due to the high frequency of operational information sharing the utilization of information technology, standardization, structured information flows, and easiness of sharing are the main factors which limits sharing of operational information. Since strategic information is often more sensitive, Trust, Fear of losing control of information, Supply chain culture, Agreements and regulations, and Management support are factors that have more influence on strategic information. Finally, industry 4.0 enables more and wider interconnection between external partners (Wollschlaeger et al., 2017), and information becomes more available (J. Lee et al., 2015). In the researched supply chain, the interviewees expected that industry 4.0 will have an effect on the factors that limit SCIS. However, it is expected to have a larger effect on sharing operational information compared to strategic information. However, industry 4.0 increases the dependency on partners and reduces the ability to switch between partners. Thus, reducing fair competition. This increased reluctantly to implement I4.0 technologies in the researched supply chain.

## **5.2 Practical implications**

This research has three main practical contributions. Firstly, this research helps to create awareness of the factors that limits SCIS. This helps managers to understand which factors in their supply chain limits the intercompany information flow. Based on the framework with the four arrogant factors (1) Connectivity (2) Individual willingness (3) Supply chain characteristics (4) Organizational facilitation. Managers can investigate which factors must be improved to enhance information sharing in their supply chain. For the cases supply chain, the factors (3) Supply chain characteristics and (4) Organizational facilitation do not seem to be a major factor. As there is an open culture, trust, and proper relationships. Furthermore, Management supports information sharing, they are not many rules, guidelines, and procedures, that limit information sharing. The researched supply chain can improve its information flows by improving the factor

connectivity. In the researched supply chain not, all partners have a sufficient level of information technology nor technological understating available. Besides the availability of IT systems and IT knowledge, there are no standardized data formats or intercompany connected systems. In the researched supply chain, the employees lacks understanding of the benefits of SCIS, and do to time constraints not all available information is used nor shared. Thus, improving the ease of sharing information is needed to improve SCIS in the researched supply chain. In addition to understanding the factors that limit SCIS, a practical implication of the research is to provide managers and employees the of most important types of information. This can used to ensure you provide supply chain partners with the needed information. For suppliers and direct suppliers Timely product information, forecasts including promotional activities, disruptions, and demand changes are most useful. For the manufacturer most important types of information are, customer demand, delivery schedules, long-term forecast, and disruption notifications. For the retailer, Product information, logistical measurements standardization, (Barcodes labels), supply chain disruptions, fluctuation in demand, and market changes are the most important types of information's. This applies for the researched supply chain and is only tested in the Dutch supply chain of pharmaceuticals, health care products, and foods for pets. The researcher expects the four factors can generally be applied in other supply chains. However, it is expected that the subfactors are different in other supply chains. Furthermore, the influence per factor might be different in other markets due to the nature of the marker or culture of the market.

### **5.3 Limitations and future research suggestions**

The main limitation of this research is the fact that the framework is only tested and revised based on a case study in one supply chain. Even though interviews were done with all tiers of the supply chain, the sample size (nine interviews) is seen as a small sample. In the sample groups different types of suppliers were included, such as the suppliers of raw material of the animal foods, but also packaging suppliers. However, on the distribution and sales side only limited differentiation are made, both distribution channels were focused on high-end retailers. Furthermore, the framework is only tested in one sector meaning that its generalisability is low as it is not tested outside of the animal healthcare and food sector. To improve the generalisability the framework must be tested in multiple and supply chains in different sectors with different characteristics. Unfortunate for this research it was very difficult to find more organizations that were willing to share information and due to limited human resources many organizations did not have the time, capacity, and willingness to participate in this study.



Therefore, suggested research is to test the generalizability with wider and a larger sample to test the generality of the framework. The researcher of this paper is confident that the four identified aggregate dimensions are similar in different supply chains however, the effect per aggregate dimensions is expected to differ in other sectors and supply chains. In addition, the smaller sample size, this research does not focus on the effect size of each aggregate dimension or the order themes. For future research it would be interesting to test the effect size of each aggregate dimension and order themes. Moreover, it researches regarding the relationships between the factors in the framework is suggested. As it is expected that improving one factor will have effect on the other factors. According to the strategic purchaser of the manufacturer (R2), Dependency reduces fair competition and ability to change suppliers in the supply market. Thus, an interesting research topic would be how SCIS increases the dependency on supply chain partners and the effects on supply chain performance and flexibility. The replicability of the factors that facilitate are not within the scope of this research. However, it is suggested that the factor connectivity, is more replicable for competitors while, individual willingness, supply chain characteristics, and organizational facilitation is more difficult to replicate. Thus, is expected to create a larger competitive advantage. In interesting future research would be to test if evidence can be found to support this hypothesis. Despite these limitations the researcher is confident that this research contributions to the existing research done on information sharing and enables interesting further research toward SCIS.

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## Appendix I: Literature review approach

Keyword	Initial hits					Used articles	Search key
		Years (hits)	Area (hits)	Articles in journals	Sorted on:		
Supply chain structure	11,819	Not limited on years	Engineering, and Business, Management and Accounting	5,786	Cited by (highest)	6	TITLE-ABS-KEY (supply AND chain AND structure ) AND ( LIMIT-TO ( SUBJAREA , "ENGI" ) OR LIMIT-TO ( SUBJAREA , "BUSI" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "cp" ) ) AND ( LIMIT-TO ( PUBSTAGE , "final" ) )
Supply chain management structure	5,518	Not limited on years	Engineering, and Business, Management and Accounting	3,164	Cited by (highest)	2	TITLE-ABS-KEY (supply AND chain AND management AND structure ) AND ( LIMIT-TO ( PUBSTAGE , "final" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "cp" ) ) AND ( LIMIT-TO ( SUBJAREA , "ENGI" ) OR LIMIT-TO ( SUBJAREA , "BUSI" ) )
TITLE-ABS-KEY (information AND sharing AND inventory AND management	791	2005 – 2021 (-)	Business, Management and Accounting (314)	226	Cited by (highest)	7	
TITLE-ABS-KEY (centralized AND information AND technology AND supply AND chain )	174	2005 – 2021 (-)	All	92	Cited by (highest)		
I4.0 (Scopus)	465	2015-2021	All	211	Cited by (highest)	6	TITLE-ABS-KEY (i4.0) AND ( LIMIT-TO ( PUBYEAR 2015 to, 2021) AND ( LIMIT-TO ( SRCTYPE , "j" ) )
I4.0 Web of Science	224	2015-2021	All	126	Cited by (highest)	2	You searched for: TOPIC: (i4.0) Refined by: DOCUMENT TYPES: (ARTICLE) Timespan: Last 5 years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI
Industry 4.0 Web of Science	17,848	2015-2021	Engineering, Computer Science, and business, management, and accounting	12,071	Cited by (highest)	10	TITLE-ABS-KEY (industry 4.0) AND ( LIMIT-TO ( PUBSTAGE , "final" ) ) AND ( LIMIT-TO ( LIMIT-TO ( PUBYEAR 2015 to, 2021) AND ( LIMIT-TO ( DOCTYPE , "cp" ) OR LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( SUBJAREA , "ENGI" ) OR LIMIT-TO ( SUBJAREA , "COMP" ) OR LIMIT-TO ( SUBJAREA , "BUSI" ) )

# **Appendix II: Interview protocol**

## **Part one: Introduction**

### **1.1 Introduction of researcher, explanation of research purpose, and privacy statement**

- Introduction of myself and the research,
- Explain the purpose and aim of the research.
- Privacy statement, the interview will be recorded and a transcript will be produced and handled with care. The recording and transcript will be deleted when the research is completed. The provided information will not be shared with any third parties or persons. The information received will be anonymised and published in the article. The results of this interview are used for academic purposes only. The interviewee has the right to stop the interview or withdraw from the research at any time.

### **1.2 Information from the interviewee**

- What is your function within the company and what are your responsibilities?
- How long have you been working for the company?
- How long have you been working in this or a similar function?

## **Part two: information sharing**

2.1 What is your view on sharing information with supply chain partners?

2.2 What do you consider as benefits of information sharing with supply chain partners and why?

2.3 What do you consider as disadvantages of information sharing with supply chain partners and why?

2.4 What information do you receive from your supply chain partners?

- Upstream and downstream

2.5 What information would like to receive?

- Why
- From which tier of the supply chain
- How come you do not receive this information?

2.6 What information do you share with your supply chain partners?

- Upstream and downstream
- Does every supplier and buyer receive the amount of information or do some receive more information. If so, why?
- 

2.7 Which factors limit the amount of information you share with your supply chain partners?

2.8 Which factors limit the amount of information you receive from your supply chain partners?

### **Part three: Connectivity**

3.1 Which connectivity factors influence supply chain information sharing?

Example: intercompany connectivity, standardized data formats, level of technical understanding, and speed of the information flows.

3.2 How does the level of information technology influence the amount of information shared?

- Difference between Strategic and operational

### **Part four: Organizational facilitation**

4.1 What organizational characteristics influence the amount of information you share with supply chain partners?

- example management- support, rules, or fear of losing control of information
- Difference in strategic or operational information

4.2 To what extent do you feel the organizational characteristics of your supply chain partners limits them to share information with you?

### **Part five: Supply chain characteristics**

5.1 Could you tell me something about the characteristics of the supply chain?

(follow-up question; how does this effect the level of information sharing?)

- Product flows
- Information flows
- Distribution of power (asymmetric or symmetric)
- Relationships with partners (trust)
- Difference in values, cultures,
- Competitiveness
- Uncertainty

### **Part six: Industry 4.0**

6.1 How would a more self-regulating supply chain influence the flow of supply chain information?

6.2 Do you expect that industry 4.0 has a larger effect on strategic information or operational information or similar effects?

### **Part seven: Summarizing questions.**

7.1 To summarize the factors that influence information sharing, could you give a top 5 of factors that influence information sharing?

7.2 To conclude and summarize this interview could you give a top five of types of information which you find the most important to receive?

### **Part eight: Ending, thanking for information**

### Appendix III: Operationalization, explanation of key concepts

Key concepts	Definition
Connectivity	Is the extent that firms are capable of collecting, analysing, and transmitting information to one another (Fawcett et al., 2007)?
Chain Characteristics	Chain Characteristics refer culture of the supply chain, power distribution, inter-firm relationships, and level of trust between supply chain partners. (Khurana et al., 2011)
Organizational facilitation	Refers to the organizational and individual attitude towards SCIS. Such as organizational culture, top-management support, and rules and procedures. Also, financial resources for operational expenditure are adapted in the concept organisational facilitation (Qi & Qingyu, 2010).
Strategic information	Strategic information is information of long-time plans which are often decided on monthly, annual, or longer terms and are less likely to fluctuate. Strategic information is often used by Management to plan for longer periods (Qi & Qingyu, 2010). Qi and Qingyu, (2010) state that strategic information has the purpose to establish a long-term partnership and commitment among the supply chain partners.
Operational information	Operational information are the information flows that are based on short-time activities which are likely to fluctuate. Operational information is often used by lower-level employees to ensure the continuous flow of goods (Qi & Qingyu, 2010).
Industry 4.0	Industry 4.0 can be defined as a connected network between the physical assets and smart computational capabilities which are self-aware, self-adaptable, self-optimizing, self-configurations, and self-regulating (Wollschlaeger et al., 2017).

## **Appendix IV: Semi structured interview data**

Supplier of packaging (sales manager (R5))	Supplier of packaging (Sales employee) (R6)	Supplier of raw materials (plant manager (R7))	Distribution channel (supply chain manager) (R9)	Internal supply chain planner (R1)	Internal Operational Buyer (R2)	Internal Strategic buyer (R3)	Internal sales manager (R4)	First concept	Second order themes
	Timely product information, forecasts, feedback on how to improve products	Availability, cost, quality, disruptions, and changes in the demand market	Product information, logistical measurements standardization (Barcodes labels), supply chain disruptions, fluctuation in demand, and market changes	Forecast of retailers to match demand			Customer demand, delivery schedules, long-term forecast, and disruption notifications.	Most important types of information	
		Trust, relationship, Understanding of benefits and importance, and availability of information	Standardization and automatization of the data usages, and time it takes to share information.	Technological understanding (mostly older employees)			Understanding of benefits, poor relationship with partners security of connected systems. Information technology to share in an easy manner, and afraid to lose sensitive information to competitors	Most limiting factors of information Sharing	
Required production specs, quality, and customer needs.			Changes in the assortment of retailers and suppliers					Received strategic information	
Changes in raw material cost			Changes in prices of suppliers					Received strategic information	
Supplier capabilities			Product and commercial information, to inform retailers.				Any market activities that cause extra demand	Received strategic information	
		The annual demand to predict if supply matches demand	Promotional schedules are received from the retailers (distribution does receive but supplier from manufacturer does not)				Promotional schedule. So, information could be forwarded to the production and suppliers. (Suppliers do not receive)	Received strategic information	
supplier lead-times		For us sharing and reviewing of prices and availability of raw material is the most important.	Product or material shortages		operational employees use information between placing the order and receiving the order.	All information what might influence the agreed delivery date.		Received operational information types	

		As quality of the raw materials differs, this is something very important to know)						Received operational information types	
A promotion schedule.	The expected level of fluctuation in the forecasted demand			More information regarding capabilities such as warehouse capacity		Real time stock levels (open to share their stock levels)		Wished to receive information	
Pikes in orders from the end customers(retailer)						Proactive sharing of changes in lead-time. Now lead-time changes are communicated after the order is placed (which is to late)		Wished to receive information	
Shortage of resources (materials, human resources) in the supply chain						More input from commercial department (internal) so this can be forwarded to suppliers		Wished to receive information	
						production flexibility of suppliers), (should be used when making promotions)		Wished to receive information	
Capabilities of the supply chain partners' systems limits SCIS beyond their direct suppliers.		A higher level of information technology increases the ability to share information as it increases the amount of data available. And makes it easier to receive data.	Proper information technology systems increase the speed and the level of information sharing. Higher level of information technology is more important for sharing operational information rather than strategic, as strategic is less likely to		Almost no information is streamlined, only based on request via mail, phone.		The lack of interconnected systems limits the amount of information shared	Information technology	Limiting factor



			changes frequently						
			Standardization of information increases the easiness of information sharing	Data standardization increase SCIS. complex data makes it vulnerable for errors thus reduces ability to share.				standardization	Limiting factor
Due to time constrains information is not shared. An inter-company connected system should and save time for the users and increase the speed of the information flow		The easiness to reach someone or provide the information influence the amount of information shared.						Easiness to share information	Limiting factor
			The level of Internal information flows effects the level of external information flows					Internal information flows	Limiting factor
both large and smaller supply chain partners are not supporting information beyond their direct tiers of the supply chain”		Defence and dominance of a player influences the level information sharing		Dominant players may influence the level of SCIS. However, in this supply chain there is no dominant player who can force changes		A dominant supply chain partner has more power to change things in the chain	More professional organizations with bigger stores share more information as the know the importance. Little stores share less. (	dominance of supply chain partner	
							Strategic information is more important to receive from important suppliers and suppliers which are not easy exchangeable.	dominance of supply chain partner	
		Supplier is very open to SCIS, does not see any harm to share information	Privacy and sensitively of the information influences the willingness to share information	The reason and objective why information is needed partner influences the willingness to share information	Trust, good contact with internal and external partners improves willingness to share information	Open to share information and willing to sharing as much as possible.		Willingness	Limiting factor
		Trust in the supplier increases willingness to share information, trust increases bases on		If the data is trusted by the company, this improves the willingness to share	When you are open towards SCIS, the other partner often opens.	In case of a new supplier, the openness towards SCIS influences		Willingness	Limiting factor

		personal relationship				the opens of the other party			
Other partners are willing to share information however it is not done because, time constrains.	Willingness is based on common sense and a long and trustful relationships,	Willingness increases when) the aim to the information is clear	There is a difference between cultures. Some cultures are more likely to share information while other cultures are more restricted	Creating a culture where information flows freely and easy through the supply chain is preferred by the interviewee		Long term relationships automatically increase trust but does not directly influence all information flows. Main importance in the usefulness of the information		Willingness	Limiting factor
		In this field., production of (animal) food there are rules that mandate to provide certain information regarding quality to ensure food safety these rules are agreed in the sales contract	Rules, procedures and commercial agreements with supply chain partners and internal agreements are in place to decide which information can be shared. These rules are decided by higher management		There are no restrictions for internal information sharing however they are less supportive about external information sharing. Employee decides what should be shared and what not, this is not based on management decisions			Rules and procedures	Limiting factor
	Information that can be misinterpreted , or is unsure or likely to change					Prices and margins are things we do not want to share		Information not willing to share	
		The fear of losing importance in the chain, as middleman, if too much information is shared, an upstream partner might cut you out of the chain and do it himself this means not all knowledge is shared.	Fear of mistreatment of the information such as selling the information the competitors				We do not want to share information where competitors can copy our product	Fear of mistreatment and losing control of information	
			Standardization of data for the entire supply chain					Suggestions to improve SCIS	

			via GS1 standards.						
			In the current unsettled supply chain, more information is requested for suppliers				The importance of information sharing increases more in uncertain market situation such as now with covid, transport and product scarcity. This is up-stream downstream.	Importance of SCIS	
	More information sharing helps to provide the best products to the customer.	Sharing information increases efficiency which reduces prices throughout the supply chain.	The right information provides the ability to respond in a timely manner			It enables special shipment, improves quantity discounts or enables lower MOQ's when information is shared	We share all information that we can to improve the processes, and cooperation.	Benefits of SCIS	
	By understanding customer needs prices can be reduced as unneeded things can be excluded		Sharing capabilities with supply chain partners improves process as partners can use these or take these into account				Sharing information helps to motivate other parties involved in the supply chain. And increasing and improving cooperation.	Benefits of SCIS	
	Sharing accurate demands increases performance and reduces waste. Because production is able to improve the allocation of resources better. This leads to better prices for customers. And increases sustainability						Strategic information sharing helps to increase future success with your supply chain partners	Benefits of SCIS	
			Operational information is only received from direct supply chain partners				Multi-tier SCIS improves processes as information can flow more freely on not from tier to tier and department to department. As mentioned	Multi-tier information sharing	

							by interviewer, information does often come to late due to multiple parties have to forward the information.		
		I4.0 can increase the frequency information is shared, instead of one annual forecast i4.0 would enable monthly send forecasts	Interviewee is sacred that the added value of flexibility, creativity of the human brain will be lost.	An issue for I 4.0 is the financial cost and thus the dependence on the other party.	decision making is seen as difficult or impossible to do by machines	Does not assume change in next 5 years. Due the complexity of the business and large product assortment with low volume. Also, fluctuation due to unpredictable influences (weather) is expected to make 4.0 more difficult to implement	I4. 0 is very useful to increase the efficiency of operational information sharing, however, strategic information should come from people, as they believe their predictions are better		I4.0