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Utilizing Cross-Enterprise Information Sharing for Mutual Benefits:
A Case Study

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Sophistication of information technology in recent decades has led to collecting and storing large volumes of information across all industries. Companies are continuously figuring out more ways to utilize this information in order to better understand customer behavior, improve every part of their operations, and as a basis of innovation in order to gain competitive advantage. Some of this information is held by other enterprises who are protecting it in order to maintain competitive advantage — unless there exists a mutual benefit in sharing the information. Information sharing across enterprise borders presents a multitude of technological, organizational, legal, financial and business model challenges that companies must solve to keep improving themselves in the best manner possible.

This study aims to understand the challenges and supporting factors companies face in sharing information in order to gain mutual benefits. As a result, a set of actions companies should implement prior to beginning cross-enterprise information sharing is presented. This study is an explorative case study focusing on a cardboard production line with six companies involved, where one company is the production line operator and the others are suppliers. The companies plan to enter an information sharing setting with the goal of improving the efficiency of the production line through predictive maintenance, and then sharing the created value between the stakeholders.

The results suggest that companies have to balance between the risk and reward of sharing information, understand the value chain setup and financial breakeven, build supporting technology for access management, security and governance of information, identify correct information and adjust their company culture, roles and processes and business model. To begin cross-enterprise information sharing, companies must identify business goals, choose their position in the ecosystem, establish partnerships and the technology setup, and define common business model, rules, contracts, operating model, processes and services.

**Keywords:** Information, Information Sharing, Cross-Enterprise, Coopetition, Supply Chain, Manufacturing

**Language:** English
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Chapter 1

Introduction

The survival of enterprises is more and more dependent on the way they collect, use and share data and information. Information is power, and is used to improve operations, to better understand customers, and as a starting point for new innovations in order to gain competitive advantage. Many enterprises are seeking an increasing amount of information to develop themselves further as rapidly as possible. Some of this information is possessed by other enterprises, and cross-enterprise information sharing is becoming an increasingly important opportunity to increase the amount of information available to the enterprise. Companies cannot ignore an integrated approach to product and service information without compromising their competitiveness. The companies that have access to the most information, and are the most proficient in utilizing that information, will have an increasing competitive advantage as competition is becoming more global [20]. Cross-enterprise information sharing is set to begin a new era of coopetition, and the boundary between competition and cooperation is becoming more obscure.

This thesis is motivated by an open issue of “How can companies utilize information possessed by other companies for mutual business benefits“. The role of information and knowledge as a vital enabler for competitive differentiation has been emphasized for over 50 years [31]. Customer needs are becoming more fragmented [39], and companies own resources are not sufficient to provide required products and services. The strategic paradox between protecting versus sharing information and knowledge suggests that a need exists for new approaches that reconcile information sharing.

A practical setting for sharing information lies within supply chains. Supply chain is defined as a system of enterprises with different roles where material, financial and information flow to both directions [10]. The external sources are of great importance to the supply chain participants, as companies need both internal and external sources to create value. However,
digitalization has disrupted every link in the value chain [3], and companies are rethinking their businesses. Through information sharing new opportunities open up, such as combining the sensor data from all manufacturers in a single production line to reduce overall deficiencies, or providing a platform ecosystem where information flows between the companies. A great source of knowledge and information exists beyond the supply chain of an organization, but tapping into this potential requires novel changes to negotiating and partnership models, common rules and processes, cross-enterprise communication.

By sharing information between companies, operational efficiencies and benefits beyond what either company are able to do on their own can be achieved, but balancing the equilibrium of risks versus reward comes with challenges. An arrangement for an enterprise is a better arrangement only when it does not benefit a direct competitor more than it does benefit the company. Thus, Pareto optimization occurs across all companies participating in a cross-enterprise information sharing setting, as every party is incentivised to optimize for their own gain, yet all parties must benefit in order for information sharing to happen. Willingness to share information is one of the largest factors preventing information sharing [5], and willingness ultimately determines the extent of sharing that will happen [22]. Information sharing also poses technological, organizational and financial challenges. This study aims to understand the challenges and supporting factors companies perceive in information sharing, and as a result a set of actions is provided to guide companies towards cross-enterprise information sharing, if the benefits outweigh the risks.

The benefits associated with cross-enterprise information sharing depend on how important information can be shared. Different industries have significant variation in how well core intellectual property can be protected by different mechanisms such as patents, and industries with strong protection will see greater results from partnerships as information can be shared in more depth [2]. These results will in turn encourage more partners to join the information sharing setting, causing a virtuous cycle. On the other hand, in industries with weak mechanisms for protection, expected gains from partnerships are relatively low and the risks in information sharing are higher. Quantifying benefits of information sharing can be difficult, and putting a value on information is case-specific. Sharing information requires careful strategic consideration on the operational and financial implications to ensure success. With the development of information and communication technology, sharing information between organizations has become significantly easier in the recent years. The information can improve the competitive advantages of all of the parties, provided that the right kind of knowledge goes
CHAPTER 1. INTRODUCTION

This study is an explorative inductive case study, and the empirical part of the study is done in the context of research project between a cardboard production line operator and its supply chain partners. Operational information from the production line operator is shared between the component providers, information system providers and a maintenance service provider in an order to improve the operational efficiency of the mill by implementing predictive error analysis. The common goal for the companies is to improve uptime of the mill with more optimal predictive maintenance utilizing the shared information, and to apportion the created value between the involved stakeholders. The key motivator for every involved company is to ensure they benefit more than risk losing in terms of competitive advantage.

The theory of this study builds on top of information sharing and coope
tition research, where a majority of research is performed in the context of supply chains. Lee and Whang lay the foundations in their study of information sharing in the supply chain [20] by identifying three distinct information transfer models: the information transfer model, the third party model and the information hub model. Additional research considers information sharing from multiple perspectives: benefits from information sharing [46], willingness and connectivity as the key dimensions to information sharing [5], barriers in information sharing [17], coope
tition in business networks [1] and platforms as means for product and service innovation [12].

As a result of the research, challenges and benefits in cross-enterprise information sharing are drawn from interviews with the participating companies. Technical advancements have made transferring information quicker and cheaper than ever before, but security and governance of shared information remain challenging. Other challenges are either strategic, organizational, legal or financial in nature. The largest challenges companies report in moving towards cross-enterprise information sharing include identifying the right information internally and externally, achieving financial breakeven, understanding new value chain opportunities, balancing risk versus reward, establishing a common operating model, building technology to ensure security and governance of information, and shifting the company culture towards a coopetitive mindset. Companies report supporting factors towards information sharing as better product development through increased availability of information, new premises for innovation, opportunities for new business models, closer partnerships and more efficient operations.

In order for companies to begin cross-enterprise information sharing, they must first identify and define business goals that are tied to information, and then define a position in the business ecosystem that the company wants to achieve. Next step is to understand the technical requirements to support in-
formation sharing, and identify partners around the business opportunities. Then, common rules, operating model, contracts and monetization model between the partners need to be agreed upon. Finally, technology for information sharing needs to be set up, and roles and processes established within the companies to support information sharing.

Research objective: What actions must companies implement in order to benefit from cross-enterprise information sharing? This research aims to provide a concrete action list that companies need to consider in order to be able to share and receive cross-enterprise information so that the reward outweighs the risks. Changing companies mindsets towards a coopetitive direction is set to change fundamental aspects in how the companies operate.

1.1 Research Questions

The broader research objective is explored here. The research questions are structured to progress from blockers and enablers towards solutions. The first two research questions are needed to understand the perspective of companies considering sharing information with other companies, and the third research question is needed to provide companies guidance towards a cross-enterprise information sharing setting.

RQ1: What factors prevent cross-enterprise information sharing in this study setting? This research question aims to identify and categorize the challenges companies perceive in cross-enterprise information sharing. The research question builds on top of existing research of the barriers in information sharing within supply chains, and the question is answered by interviewing companies participating to the research project.

RQ2: What factors support cross-enterprise information sharing in this study setting? After the key factors that prevent cross-enterprise information sharing are identified and categorized, this research question aims to highlight the benefits companies perceive in cross-enterprise information sharing, in order to help companies weigh pros and cons.

RQ3: What actions do companies need to implement in order to enter a cross-enterprise information sharing setting? Finally, with the information collected in prior research questions, this research question
CHAPTER 1. INTRODUCTION

aims to identify a concrete list of actions a company should implement prior to entering a cross-enterprise information sharing setting.

1.2 Structure of the Thesis

This thesis is structured as follows. In the second chapter the research design is explained in detail, and chosen research method is rationalized. In the third chapter relevant literature in cross-enterprise information and knowledge sharing, coopetitive business models, data governance and information sharing in supply chains are presented to both educate the reader on the subject and to position this study in the field. In the fourth chapter, the case study setting, roles of participating companies and operations of the cardboard production line are explained. In the fifth chapter, the findings of the study are presented according to the research questions. Finally, in the sixth chapter, the findings are discussed and tied to the general research body, contributions of results are drawn, and potential further research avenues are identified.
Chapter 2

Methods

The structure of this chapter is as follows. First, case study and qualitative research as research methods are explained. Then, the chosen research method and the structure of the research are described in detail, including how the empirical information was collected and analysed. Finally, limitations of the research are evaluated.

2.1 Case Study

Case study is a research method for a detailed examination of a subject of the study where data is collected through observation. Case study allows for testing theories in an unmodified setting. The strengths associated with case study research due to linkage with empirical evidence are novelty, testability and empirical validity [8]. Case studies can be divided into four different purposes: Exploratory, Explanatory, Descriptive, and Improving [34]. An exploratory case study is used to seek new insights, to find out what is happening, and to generate ideas and hypotheses for new research. An explanatory case study is used to seek an explanation to a problem or a situation through a causal relationship. A descriptive case study is used to portray a situation or a phenomenon. An improving case study is used to improve an aspect of the studied phenomenon.

Case studies utilize different approaches for collecting and analysing data and drawing generalizations. These approaches can be categorized into three different approaches: inductive, deductive and abductive [7]. An inductive approach moves from data to theory. In an inductive approach the data is first collected, and then patterns are searched, and theories that explain the patterns formed. A deductive approach is in reverse order. An abductive approach begins by considering the facts or particular observations, that are
CHAPTER 2. METHODS

then used to form hypotheses that relate them to a fact or a rule that accounts for them. As a result, the facts are correlated to a more general description, which then relates them to a wider context.

Case studies can be structured in five different steps [35]. The first step is designing the case study, where the study is planned and the objectives are defined. The second step is to define the procedures and protocols for collecting data. The third step is to collect the evidence by executing the data collection on the case that is studied. The fourth step is to analyse the collected data, and the fifth step is to report the results. Common ways of sampling data in qualitative research is done by either purposeful sampling or convenience sampling. In purposeful sampling, participants that can provide detailed and deep information about the studied phenomenon are used. In convenience sampling, easily accessible and convenient participants are recruited. This research utilises purposeful sampling.

In order to improve validity and reliability of the findings, data should be collected through various different methods. Triangulation refers to combining several research methods to study the same phenomenon to provide a wider picture of the case. Triangulation is principally important for qualitative data, but can be utilized for quantitative data as well. Triangulation can be defined in four ways[41]: Data triangulation, Observer triangulation, Methodological triangulation and Theory triangulation. Data triangulation utilizes multiple sources of data that are collected at different points of time. Observer triangulation utilizes more than one observer. Methodological triangulation combines different methods for collecting data, and theory triangulation uses different viewpoints or theories.

2.2 Qualitative Research

Qualitative research can be used to answer questions ”Why” and ”How”, whereas quantitative research is more suited to answer questions of ”What”, ”Where” and ”When”. Qualitative research was chosen as the primary tool for this study due to the complexity of the problem and low quantity of participating companies. Interviews are the most common way to collect data in qualitative research. Interviews can be defined as a way to collect perceptions, impressions, opinions and historical data about a phenomenon[38], and can be either structured, unstructured or semi-structured. In a structured interview the subjects are very specified, and the interviewer asks all the questions. A structured interview is focused on finding relations between constructs. The objective of a structured interview is descriptive and explanatory [35]. An unstructured interview has a broadly defined topic
and the interviewee also takes part in asking questions. An unstructured interview is focused on how an interviewee qualitatively experiences a phenomenon, and the objective is exploratory. Semi-structured interviews have both a descriptive and explanatory objective, and focus on how phenomenons are experienced by individuals both qualitatively and quantitatively.

There are multiple ways to analyse qualitative data, such as content analysis, narrative analysis, discourse analysis and qualitative data coding [38]. In this study, qualitative data coding was chosen to extract quantitative variables from qualitative data. Coding is used to organize the data to different themes, and to view the data from multiple angles. Qualitative data was chosen as it is richer than quantitative data, and the amount and diversity of information and thus the confidence in results can be increased. The objective of data analysis is to draw insights and to form theories and conclusions from the data with a clear chain of evidence. Two different parts for qualitative data analysis are hypothesis confirmation techniques and hypothesis generating techniques [38]. In hypothesis generating techniques hypotheses are generated from statements or propositions in the notes that can be supported by the data, while in hypothesis confirmation techniques the data sources are triangulated to build evidence to support hypotheses.

Robson [33] presents a sequential list of qualitative data analysis. The first step is coding the initial data set, and then comments and reflections from the author are added. Then, the data is processed to identify similarities, differences, themes and patterns within the sub-groups. The identified themes and patterns then guide data collection in the further phases, and through each iteration more generalizations can be formed. When the data has been coded the hypotheses can be identified and theories built to create a formalized body of knowledge. There are multiple ways to conduct data analysis, such as Template, Quasi-statistical, Immersion and Editing approaches. Template approaches were chosen for this study, and they utilize developing of a coding template in order to organise the data to different themes.

### 2.3 Research Design

This section presents the strategic decisions guiding how the research is carried out. This includes the phenomena under study, selection of methods, data collection and data analysis. This study is an explorative inductive case study that explores the motivations, challenges and a concrete list of actions that companies should implement for sharing information and therefore value between other companies. The study specifically aims to identify the main requirements, problems and key success factors in order to construct
a clear set of actions that the case companies can utilize to improve their common partnerships and individual businesses. Extending the operations towards information sharing and cocompetition driven business requires a deep analysis from all participants on their needs and state of current operations, and adopting an information sharing model requires thorough understanding of the whole value chain setup. To narrow down the scope in this thesis, generalized models suitable for the case companies are provided as a result, but applying the models in practice remains out of scope. Additionally, the case companies in the study are used as a general reference for drawing insights, but operational improvements implemented during this study in their respective projects is not a part of the scope.

2.3.1 Data Collection

Interviews performed with all the participating companies are the main source of information in this research. Data is also collected through operational documents in order to supplement the interview data and to verify the theories. Data triangulation is implemented through interviewing individuals that are in different positions in the case companies, and methodological triangulation is implemented through the collection of data regarding the manufacturing process from internal documents. The author also made observations in the analysis. Interview was chosen as a data collection method because the study tries to understand barriers and supporting factors through individual perceptions.

The interview is semi-structured and has a set of open-ended questions that allow the studied objects to be deeply explored [38]. The interviews are performed once per interviewee, with one to two interviewees per participating company. There are in total seven interviews from three different companies. The interviewees consist of managers responsible for the company’s part in the information sharing project, with individual focus areas varying between strategy, technology and sales. The interviews are performed in Finnish and an audio record for each interview is generated, that are afterwards translated into text. The interviews begin with a set of background questions that allow the data to be coded per subject. The structure of the interview is created according to the areas under study, and is as follows:

- Background: Role of the company within the case study, and the interviewee in the company.
- Information: What information the company possesses and plans to share.
• IT systems: How information is collected, stored, analysed and shared. How data security and access management are implemented.

• Barriers for sharing information: What prevents the company from sharing information.

• Supporting factors for sharing information: Business goals and motivators for sharing information.

• Models for accruing value: Models for how commonly created value can be shared between the participants.

The background section gathers information on what the role of the company is in the case study setting, and what the individual is responsible on within the company. The information section aims to understand what information the company is currently collecting and for which purposes, what information they would like to have, and what information they plan to share to other companies. The IT systems section focuses on how information is handled, and what concerns companies have related to information management. Barriers for sharing information continues on the concerns that companies have towards information sharing on a higher scale: identifying factors within the company that are slowing or stopping information sharing from happening. Supporting factors section, on the other hand, is focused on understanding why the companies want to enter the information sharing setting in the first place, and what concrete benefits they see ahead. Finally, models for accruing value aims to identify the entire space of different models that can be used to align companies and accrue generated value between all participants.

Interviewees were able to provide more in-depth answers based on their areas of expertise. This was the main reason for why template analysis was chosen as the method for data analysis, as the data can be organised based on the different roles of the interviewees. The technical staff are most knowledgeable of the manufacturing process and technical details. Strategy directors are more aware of the business and organizational model, and financial implications of information sharing. The interviews were used as a main method to collect data because qualitative data was required to answer the research questions, as they require opinions and insights from the interviewees.

2.3.2 Data Analysis

Template analysis was chosen as the method for data analysis, as it can be effectively used to compare multiple perspectives of different participants. As
the research focuses on multiple themes and on multiple groups of interviewees, template analysis was seen as the most suitable approach. Template analysis is a data analysis method for organizing and analyzing qualitative data thematically[18]. The data analysis is implemented by coding the data based on the areas under study: barriers in the information sharing setting, supporting factors for the companies in sharing their information, and suggested actions the companies consider they need to implement before participating to information sharing. The data is coded multiple times through iterations, with each iteration identifying more subthemes and adding more depth to the template. As a result, the data is structured under multiple themes that each provided granular insights within that theme, and all the information related to each theme is identified. The end result of the template analysis is a template structured based on the themes under research that allows the research questions to be answered as comprehensively as possible. The hypotheses built from the final template are then validated by the original data from interviews to ensure that no sections were left out in the template, and that there are no conflicts in the findings and the answers to the interview questions.

2.3.3 Limitations

The findings of the research cannot be entirely generalised to other settings due to the chosen research method, low amount of interviews and the specific setting of the case. In this case, the limitation applies to all the research questions as they all rely on the data collected through interviews. Only two types of triangulation were used, and the reliability of the results would have increased by utilizing other types of triangulation methods and expanding the amount and scope of the interviews. However, multiple persons with different roles were interviewed, and additional documentary data was collected to support the interviews, such as operations data related to the cardboard production line, information systems environment, business models of the companies and roles of the case companies.

A large amount of qualitative data was gathered to understand the phenomena as well as possible, and the analysis of data was done systematically. The main findings of the research should be valid for similar scenarios outside of the context of the thesis. The challenges and supporting factors in cross-enterprise information sharing should be explored by any company considering taking part into a cross-enterprise information sharing setting. The relevancy of identified action points towards information sharing are very case-dependent, and companies can participate in cross-enterprise information sharing on varying levels of integration. However, the action points need
to be implemented to some extent in any scenario of the setting.
Chapter 3

Theory

This study builds on top of research on information sharing, coopetition, business platforms and data governance. The main research body can be summarized as follows. Lee et al. [20] [22], Zhou and Benton [46], Khurana et al. [17], and Yu et al. [45] study information sharing in the context of supply chains, considering aspects such as benefits from information sharing, the process of information sharing, different types of information and the challenges in information sharing. The general consensus is that information sharing is necessary for optimal supply chain performance, but requires companies to overcome organizational, technological and financial barriers. The challenges and benefits are further discussed in the following sections.

Myers et al. [28] and Croom et al. [5] study information and knowledge sharing between organizations, and come to the conclusion that information sharing can improve the competitive advantages of all of the parties, provided that the right kind of information goes back and forth. Loebbecke [25] studies protecting versus sharing knowledge and information and notes that companies should find a balance between the two.

Tsai [42], Luo [26] and Bengtsson and Kock [1] study coopetition from three perspectives: global, within a business ecosystem, and from the perspective of social structures. In a coopetitive setting, companies cooperate with competitors in order to reach a higher value creation if compared to value created without the interaction. The authors present different situations of coopetition, and strategies companies can utilize to capitalize on different settings.

Gawer et al. study how platforms can impact product and service innovation [12], and Parker et al. [30] study how platform sponsors can optimize platform access and control. Platforms enable creating microeconomies through information sharing with defined operational rules and contracts. When data is seen as a resource and capability, companies are empowered to
This chapter is structured as follows. First, different viewpoints on the barriers related to information sharing are analysed, and presented challenges are segmented and described on a high level. Then, data governance is explored in more detail to understand information management in more detail. Second, studies related to benefits from information sharing are analysed, and motivating factors described to holistically understand benefits that companies want to achieve with information sharing.

### 3.1 On Cross-Enterprise Information Sharing

Information is power, and many companies hold to their information in order to maintain competitive advantage. This information held by companies holds a tremendous amount of potential if shared with other companies — yet, sharing information requires a company to understand the value of both the output and input in the sharing in order to weigh risks and benefits. This section outlines the main research body on information sharing between companies, and following sections further dive into the challenges and benefits of information sharing.

Information sharing between companies is most researched in the context of supply chains, where companies benefit from better alignment of their business processes. Lee, in his study “Information sharing in a supply chain“ that can be considered the baseline for information sharing within supply chains, segments types of information sharing in supply chains into six different categories: inventory level, sales data, order status for tracking, sales forecast, production and delivery schedule, and other information sharing [20]. Other information sharing includes, for instance, performance metrics and capacity.

Lee presents three different models of information sharing: information transfer model, third party model, and information hub model [20]. In the first model, a partner transforms the information to another partner who maintains the database in a transactional manner. In the second model a third party whose function is to collect information and maintain a database for the supply chain is present, and the transactions are handled through this party. The third model is similar to the second model, but the third party is replaced by a system.

Zhou and Benton study three aspects of information sharing in order to understand the underlying benefits [46]. The aspects are information sharing support technology, information content and information quality. The authors note that how information is used defines the performance in infor-
information sharing, and managers should not only focus on the hardware and software. The information technology investment is not enough, but the appropriate information needs be identified and shared. The quality of information measures the degree of how the information meets the needs of the organization. The authors describe nine different characteristics of information essential for efficient information sharing: accuracy, availability, timeliness, internal connectivity, external connectivity, completeness, relevance, accessibility and frequently updated information.

While sharing information with companies that are not directly competitors can be viable, often sharing information can be more valuable for companies that have overlapping businesses or are in similar or same value chain. Because of this assumption, coopetition is considered as a baseline scenario for information sharing. While the competition aspect of coopetition does not totally have to overlap, any current or future overlap can weaken companies positions when the competitors advance their operations. Luo has built an overall framework to analyze coopetition [26]. The framework presents a typology for understanding intensity and diversity of coopetition with major global rivals. Luo has segmented competition to four situations: contending, isolating, partnering and adapting, to describe the varying degrees of coopetition and competition between rivals.

Figure 3.1: Intensity of coopetition with a major global rival [26]

A contending situation exists when a two companies compete for market power, competitive position and market share in critical international markets, and maintain a high level of competition and a low level of coop-
CHAPTER 3. THEORY

An isolating situation exists when a company maintains a low level of competition and a low level of cooperation with another leading global player. In this scenario the company acts virtually independently in the international markets. A partnering situation exists when a company maintains high cooperation and low competition with another company, in search of joint synergies created by the complementary resources and capabilities between these two companies. For this scenario to occur, a high resource complementary and low market commonality are necessary conditions. An adapting situation occurs when two companies are dependent on each other to achieve their respective goals. In this scenario, a high level of cooperation and a high level of competition are maintained.

Figure 3.2: Common services for IIoT data-management and application enablement[32]

Industrial Internet Consortium studies service provider and business model disruption in the Industrial Internet of Things (IIoT), and modeled interoperability of IIoT platforms [32]. The study identifies the main requirements of interoperability as data collection, data storage and data publication. Further on, more advanced features for interoperability include data discovery, data brokering, protection of data-ownership rights, and tools to track data- and resource-usage for charging purposes. The requirements identified in the context of IIoT also help understand what features companies must think of when planning the details of information sharing.

Parker et al. present a framework for helping companies understand the optimal levels of openness and intellectual property duration in a open platform ecosystem [30]. The research question supposes that a firm in charge of a business ecosystem is in charge of a microeconomy, and aims to understand how open that economy should be to achieve the highest growth rate. As a
main conclusion, the authors built a parameter-based function to maximize platform sponsor profit, taking into account variables such as share of platform openness, coefficient of reuse, numbers of developers and value per unit of output.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>σ</td>
<td>Share of platform (% open to developers)</td>
</tr>
<tr>
<td>t, δ</td>
<td>Time until exclusionary time expires (discount δ = e^{-t})</td>
</tr>
<tr>
<td>α</td>
<td>Technology in Cobb–Douglas production</td>
</tr>
<tr>
<td>F, c</td>
<td>Fixed and marginal costs</td>
</tr>
<tr>
<td>k</td>
<td>Coefficient of reuse</td>
</tr>
<tr>
<td>N</td>
<td>Numbers of developers</td>
</tr>
<tr>
<td>p</td>
<td>Price of individual developer applications p = v(1 - δ)</td>
</tr>
<tr>
<td>v</td>
<td>Value, per unit, of developer output</td>
</tr>
<tr>
<td>V</td>
<td>Stand-alone value of sponsor's platform</td>
</tr>
<tr>
<td>y_i</td>
<td>Output of developers in stage i and input to developers in stage i + 1 with y_i = ky_{i-1} and y_0 = S</td>
</tr>
<tr>
<td>ω</td>
<td>Probability of success for a given innovation</td>
</tr>
<tr>
<td>π_{ps}</td>
<td>Platform sponsor profit function</td>
</tr>
<tr>
<td>π_d</td>
<td>Developer profit function</td>
</tr>
</tbody>
</table>

\[ π_{ps} = V - σV + \frac{1}{2}py_1 + δ\frac{1}{2}py_{2s} \]  \hspace{1cm} (1)  
\[ π_d = \frac{1}{2}py_1 + δ\frac{1}{2}py_{2s} \]  \hspace{1cm} (2)

With these variables, the Equation (1) can be used to calculate platform profits as the sum of platform sales, first-stage royalties and discounted second-stage royalties net of subsidy costs. The platform sponsor has two options to monetize the platform: closing the platform increases the sponsors ability to charge for access, while opening the platform increases developer availability to build upon it. The platform sponsor can also adjust how long third-party developers on the platform can retain their rights for their IP. The longer the period, more royalties the developers and the sponsors earn, and the shorter the period the quicker their innovations become a public good upon which other developers can build. As a summary, platforms need to be configured case-by-case, weighing the optimal balance of access and control of platform participants, but also the level of exposure of internal resources to external innovators.
3.2 Barriers for Cross-Enterprise Information Sharing

Barriers to information sharing are studied from the perspective of information sharing in supply chains [17] [20], global knowledge sharing [28], willingness to share information [5], individual barriers [15], protecting versus sharing information [25] and technological feasibility [16][37].

Croom et al. [5] discovered that while information sharing can be beneficial for organizations, it seldom delivers on its promise to enable cohesion within the supply chain as many companies overlook willingness to share information. As information is power in today’s business world, companies perceive sharing information as potentially losing competitive advantage — yet a large amount of potentially useful information that could be used to enhance decision making remains unavailable if the information is not shared. The authors suggest that in order for companies to leverage information sharing as a competitive advantage, companies need to maintain a balanced perspective, avoid technology traps, match technologies for specific value-added capabilities, understand the processes, performance measures and people of technology implementation, and invest proactively in a culture of willingness. The authors note that implementing advanced technologies to achieve high levels of connectivity is just the beginning, and technology must be tied to specific capabilities, and the human dimension of information sharing must be recognized as critical as the technology.

Lee identifies main barriers in information sharing as aligning incentives of the different partners, and haggling over how much positive gain from the information sharing each party can achieve [20]. Lee also notes that confidentiality of information sharing is crucial, using an example of one supplier and two manufacturers who compete in the final product market. Either manufacturer would not share information, like sales data, with the supplier unless it is guaranteed that the information is not leaked to the other manufacturer. Finally, building the cross-organizational information system is costly, and timeliness and accuracy of the information needs to be ensured.

Khurana et al. study barriers in information sharing, and divide the barriers into the following categories [17]. The order is not of importance, as every case has its own barriers that need to be overcome. The barriers pose a lot of interdependencies, and what seems like a technological barrier might originate from the lack of trust of individuals.

- Managerial
- Organizational
Individual
financial
Socio-cultural
Technological

Managerial barriers arise when managers do not realize the real benefits of information sharing, have knowledge of the area, or have confidence in
information sharing. As a result, sufficient investments are not made and a culture for sharing is not built. Curry and Moore [6] suggest that support of senior management is required to build an information sharing culture. Fawcett et al. [9] suggest that lack of trust makes it difficult to share sensitive information, as managers cannot ensure that other parties protect the information from misuse.

Organizational barriers originate from the attitude of organizations towards information sharing. Information sharing requires a radical mindset shift from individuals organizations, from protecting their own assets towards seeking to achieve greater common good. Organizations fear losing competitive advantage and thus market position in case technical information is shared with other parties. Ceccagnoli et al. [2] report that in industries with weak mechanisms for protection of core intellectual property, expected gains from partnerships are relatively low. Tsai [42] reports that organizations with a strong centralized hierarchical structure are significantly less likely to share information in a supply chain.

Individual barriers originate from behavior and actions of individuals or groups. "Individuals feel that power, ownership and privilege of possessing crucial information are lost when they share that information". This can result into information pathologies, where individuals preserve information from co-workers to show superiority [15]. The interference of human element in complicating cross-enterprise information sharing is reported in a study by Childhouse and Towill [4]. Several managers expressed that problems in implementing information sharing were rooted in individuals rather than technological impasses, and that technological problems are easier to solve. Individuals might fear sharing incorrect or ambiguous information, but they might also fear becoming redundant when the information gets shared.

Financial barriers consist of the costs related to supporting the infrastructure required for information sharing and redesigning internal organizational and technical processes, and the difficulty of understanding bottom line value gain of the information sharing. Additionally, product distribution channels might need to be changed, and staff trained to achieve efficient information sharing.

Socio-cultural barriers often stem from different working methods, techniques and corporate culture from organization to organization. Companies need to be at a certain level of information culture in order to be able to collect, share and manage information, but also to be able to trust each other to handle the information correctly.

Technological barriers have shifted from collection and integration of information to management and analysis of information as a result of recent advancement of information technology. The availability of information is so
high that organizations spend a lot of time in figuring out how to use the information. While collecting and integrating information between companies is a possible barrier for companies with unsophisticated IT infrastructures, lack of trust in information technology of other parties can be present in every case.

Loebbecke et al. study the strategic paradox of protecting versus sharing knowledge between organizations [25]. The authors propose four configurations of inter-organizational knowledge sharing for managing the paradox. The four configurations are the combinations of two types of knowledge and two modes of knowledge sharing. The types are explicit knowledge, which refers to concepts, information and insights that are specifiable and can be formalized into rules and procedures [43], and tacit knowledge, which refers to insights and skills that are embedded in individuals or organizational context. The modes of knowledge sharing are unilateral, that takes the characteristics of one-way traffic, and bilateral, which is reciprocal in nature. The authors note that companies involved in inter-firm knowledge sharing need to develop capabilities and routines to understand and handle complex knowledge sharing across their boundaries, and that knowledge often spans number of dimensions and is hard to compartmentalize into discrete categories, which would be more suitable for sharing.

In bilateral sharing of explicit knowledge, participating companies “face a quid pro quo balancing act of sharing and receiving knowledge”, and strive for competitive advantage without diluting their unique resources. Each partner might aim to decrease the amount of value of the information the company shares, while also trying to maximize the value the company receives. The article suggests that companies asking for clarifications and additional contextual information beyond the knowledge sharing covered by the contracts is a way to do this.

In bilateral sharing of tacit knowledge, companies might be tempted to deviate from the initial agreements due to partially conflicting interests. An example is delivering limited and possibly inaccurate information, meanwhile enhancing the reception of valuable knowledge. This causes tension in relationships, and potentially escalates uncertainty and distrust [13]. Another issue is managing the coordination between organizations, and preventing individuals from leaking private information into the public domain.

Data security is a potential concern of many companies planning to share their information with other stakeholders. Sadeghi et al. study security and privacy in industrial internet of things, and came to the conclusion that as these systems generate, process and exchange vast amounts of security-critical and privacy-sensitive data, they are attractive targets of attacks [37]. As smart factories can self-organize their production systems even across
company borders, they need to be sufficiently enhanced in terms of security from multiple stakeholders. The authors note that today’s internet of things systems are not sufficiently secured, and a holistic cybersecurity framework covering all abstraction layers across all platform boundaries need to be implemented. Existing security solutions are mostly not appropriate as they do not scale to the large networks of heterogeneous cyberphysical systems with constrained resources and real-time requirements.

Data governance is a set of practices that ensures data assets are managed comprehensively within an organization, and plays a major role when planning for cross-enterprise information management. Difference between governance and management can be differentiated as follows [16]: governance refers to what decisions must be made to ensure effective management and use of IT, and who makes the decisions. Management involves making and implementing decisions. Therefore, governance establishes who in the organization holds decision rights for determining certain standards, and maintenance involves determining the actual metrics employed. Data governance can be divided into ten different management functions [27]:

- Data quality - Defining, monitoring and maintaining data integrity, and improving the quality of data.
- Data architecture - The overall structure of the data and resources related to it.
- Data storage and operations - Physical data assets storage, deployment and management.
- Data modeling and design - Analysis, design, building, testing and maintenance.
- Data Security - Ensuring privacy, confidentiality and appropriate access.
- Data Integration and Interoperability - Acquisition, extraction, transformation, movement, delivery, replication, federation, virtualization and operational support.
- Documents and Content - Storing, protecting, indexing, and enabling access to data found in unstructured sources (electronic files and physical records), and making this data available for integration and interoperability with structured (database) data.
• Reference and Master Data - Managing shared data to reduce redundancy and ensure better data quality through standardized definition and use of data values.

• Data Warehousing and Business Intelligence - Managing analytical data processing and enabling access to decision support data for reporting and analysis.

• Metadata - Collecting, categorizing, maintaining, integrating, controlling, managing, and delivering metadata.

IT assets and information assets can also be differentiated [16]: IT assets refers to technologies, such as computers and databases, that help support the automation of well-defined tasks. Information assets refer to facts that have value or potential value that are documented.

3.3 Benefits from Cross-Enterprise Information Sharing

Companies are always looking for ways to grow their business while minimizing the risk involved, and benefits of information sharing are crucial to understand in order to justify the risks. Zhou and Benton [46] researched 125 North American manufacturing firms, and came to the conclusion that effective information sharing significantly enhances effective supply chain practice and reduces uncertainties. The authors found out that in order to utilize the benefits on information sharing, effective supply chain practice is very important. This includes, among other things, standardization of the supply chain processes. The higher the level of information sharing, the more important the effective supply chain practice is.

Hau Lee came to the conclusion that information sharing can tighten the coordination within the supply chain, aid in decision making, and optimize the chain-wide performance [20]. Lee found that top performing supply chains have three qualities: they align the interests of all members in the supply chain in order to optimize common performance, they are agile to respond to short-term changes in demand or supply quickly, and they have adaptability to adjust supply chain design to accommodate market changes [21]. Lee presents four methods to improve alignment of the supply chain:

• Provide all partners with equal access to forecasts, sales data, and plans.
• Clarify partners roles and responsibilities to avoid conflict.

• Redefine partnership terms to share risks, costs, and rewards for improving supply chain performance.

• Align incentives so that players maximize overall chain performance while also maximizing their returns from the partnership.

Kulp et al. study manufacturer benefits from integration with retail customers, and note that solely sharing information on either inventory levels or customer needs is associated with higher manufacturer performance measures [19]. Li et al. also come to the conclusion that information sharing can consistently improve supply chain performance under the condition that demand remains relatively stable [23]. When the variance of demand is high, the performance of information sharing varies. Croom [5] found that real-time connectivity provided by information sharing empowers managers to detect environmental trends and inflection points earlier, helping companies respond to changing competitive rules. The real-time connectivity also helps companies monitor customer behaviour on a continuous basis.

Gawer and Cusumano study industry platforms, and state that platforms facilitate the generation of a potentially very large number of complementary innovations by tapping into the innovative capabilities of many external actors [12]. While innovation through cross-enterprise information sharing hasn’t been researched in detail, knowledge sharing is known to lead to a more efficient innovation process. Wang and Wang studied 89 high technology firms, and found that both explicit and tacit knowledge sharing practices facilitate innovation and performance [44]. Explicit knowledge sharing has more significant effects on innovation speed and financial performance, while tacit knowledge sharing has more significant effects on innovation quality and operational performance.

Ceccagnoli et al. [2] study cocreation of value in a platform ecosystem, and come to the conclusion that “joining a major platform owner’s platform ecosystem is associated with an increase in sales and a greater likelihood of issuing an initial public offering”. The research highlights that value cocreation and appropriation are not mutually exclusive strategies in interfirm collaboration. The authors also note that individuals joining these platforms that have not protected their innovations should be cautious about initiating partnerships. Different industries have significant variation in how well core intellectual property can be protected by different mechanisms such as patents, and the authors note that industries with strong protection will see greater results from partnerships. These results will in turn encourage more
partners to join the ecosystem and thus customers, causing a virtuous cycle. On the other hand, in industries with weak mechanisms for protection, expected gains from partnerships are relatively low.

Yu et al. found that increasing information sharing among the members of a decentralized supply chain leads to Pareto improvement in the performance of the entire chain [45]. Pareto efficiency is a state of allocating resources in such a manner that any individual cannot be better off without making at least one individual worse off. The authors note that with sufficient sharing of information, the bullwhip effect of forecast inefficiencies in supply chain performance can be diminished. As a result, information sharing can lead to performance improvements in inventory level and cost with increased information sharing.
Chapter 4

Background

This chapter elaborates the context of the research case: the research setting, operations of the cardboard production line, information environment, and roles and responsibilities of the participating companies.

4.1 Case Description

Stora Enso operates a cardboard production mill in Imatra, Finland. A single cardboard production line producing liquid packaging cardboard was chosen as the topic of this research project. The cardboard production line consists of components from multiple manufacturers such as valves, automation system and motors. The manufacturers provide components, but also provide ownership of the data generated by these components to the operator of the production line. In total five companies participate in the research:

- Company A: Operator of the production line.
- Company B: Manufacturer of the production line.
- Company C: Maintenance service provider.
- Company D: Valve provider.
- Company E: Electrical and software systems provider.

Company A operates the production line, and every other company in this case study is a customer of Company A. Company A currently is the sole receiver of value from production output of the production line, and pays other companies based on the services they provide. Company A also decides what data they want to share between other companies, and can
purchase equipment with the rights for all of the data related to that equip-
ment. Company B is the manufacturer of the production line, and provides
the automation system used to operate the production line. Company C
performs maintenance for the production line in three cycles: during the op-
erative action when the machine is running, during a weekly maintenance
period, and during larger renovation every few years. Company D provides
valves for the production line. The entire production line heavily depends
on valves, which are utilized to measure the pulp mass consistency, surface
height, temperature, and to control raw material feed in different parts of
the process. Company E provides electrical systems and software platform
for the production line.

4.1.1 Cardboard Mill Operations

One cardboard production line was chosen for this research. The cardboard
production line produces liquid packaging cardboard that consists of three
different layers. The top and bottom layers are made from pulp, while the
middle layer is made from a mechanical mass with wood fibers, providing
stiffness and strength.

The following figure depicts different phases in cardboard production.
Cardboard is produced by blending selected raw materials into an aqueous
pulp mixture, laying the mixture into a flat fibrous web, and strengthening
the mixture by draining water. These processes are done in the former, head-
box and wire section of the production line. Then, the mixture is pressed and
drained heavily to produce a final dry product. Afterwards, if manufacturing
liquid packaging, the dry product is coated with a thin layer of polyethylene
plastic. Finally the cardboard is rolled for transportation and cut. The main
difference between paper and cardboard manufacturing is that cardboard has
multiple layers and larger grammage.

Figure 4.1: Cardboard production line

In this study setting the common goal for all the companies is to reduce
errors in the machine in order to maximize uptime and thus the production
capability of the production line. Condition monitoring has proven to have a
strong impact on the output of the machine, and therefore the profitability of
the operator. Maintenance is performed in three cycles: during the operative action whenever the machine is running, during a weekly maintenance period and during a larger renovation every few years. The common goal for all the companies is to build a system for predicting errors in advance by combining operational data from all sensors in different parts of the machine, and then perform preemptive maintenance to prevent larger incidents from happening.

The benefits of condition monitoring are improved productivity, better maintenance planning, better utilization of downtime, reduction to unpredictable downtime and longer lifespan of the production line. Additional minor benefits include reduced amount of required spare parts and reduced need to open up different parts of the machine when performing maintenance. Important measures to predict upcoming operational errors are bearing vibration, temperature and particle wear analysis. Approximately 90% of bearing damage can be detected months before destruction of the bearing through bearing vibration analysis [24].

4.2 Information Technology Environment

In the study setting the machine operator has built a virtual cloud environment with multiple databases. The other participating companies are uploading data from their components to the cloud. In the cloud environment, predictive analysis is performed on all of the data. The virtual cloud environment is separate from the operational system that is needed for daily operations of the procession line, but the data is partially the same. The production line operator is the company with admin access to the systems, and they provide access for the participating companies.

4.3 Goals of the Case Study

The main goal for all the participants in the case study is to increase the output of the production line in order to create more value, that is then shared between the participants. In order to increase the production output, either uptime or production speed has to be increased. A secondary benefit is to reduce the maintenance costs. For this case study, improving the uptime is a priority. Uptime can be improved by reducing the amount of operational errors and thus reducing the production lines time under maintenance. Maintenance can also be performed with more detail, as with more knowledge on the stability of different components, predictive maintenance
can be performed on seemingly working components that are reporting deteriorating performance metrics.

Having a constant stream of performance metrics from all of the components in the production line and understanding the interdependencies between different components is crucial in order to build a predictive maintenance system. For instance, a leaking valve might result into a larger operational error if not treated in time. To understand interdependencies, having as much data as possible available from every component is necessary, and every stakeholder must be incentivised towards sharing this information. This formulates the main research area of this thesis: what motivates companies to give the information to other parties, when their financial gain can be unclear?

While the case companies have their own goals of operational improvements, this research is focused on drawing general insights on cross-enterprise information sharing in order to build a concrete action list for any company that is considering cross-enterprise information sharing as a part of their strategy. Thus, case-specific operational improvements are not a focus of the research.
Chapter 5

Findings and Analysis

This chapter presents and analyses the main findings of the research. The chapter is structured according to the research questions: first, challenges in sharing cross-enterprise data are segmented and explained. Then, factors supporting cross-enterprise data sharing are presented. Finally, a set of action points to guide companies towards cross-enterprise information sharing is presented.

5.1 Barriers in Sharing Cross-Enterprise Information

Companies have traditionally been protective of their own information in order to maintain their competitive advantage. This section aims to provide a deeper understanding of what factors prevent companies from performing cross-enterprise information sharing, in order to be able to break these barriers down to tap into additional value the information sharing holds.

5.1.1 Competitive Advantage

Every interviewed company is concerned of maintaining competitive advantage to some extent when planning information sharing. Companies have not protected all of their core intellectual properties with patents or other mechanisms, but are instead keeping information only within the company. Even if companies have patented certain technology, they are concerned on actual strength of the legal protection. Companies are not only concerned about other stakeholders in the sharing ecosystem accessing their information, but the information leaking to third parties through another company.
Some data can be sensitive, such as planning information, and it is very close to our core intellectual property. If a country with lower cost of labor gets access to this information, nothing prevents distortion of competition.

—Company B

Data related to our core business needs to be guarded.

—Company C

Information that companies possess has varying levels of importance. The case companies report that some information, such as planning information related to how the products are built, can be extremely valuable to direct competitors. Information closer to key intellectual property can only be shared when the company can be certain that the benefits outweigh the cons, and that the information will not leak from other companies. Information that is not close to key intellectual property can be shared more flexibly.

5.1.2 Governance of Shared Information

Data governance related to shared information has a lot of open questions on the managerial level. Most crucial practices have not been defined, such as access management or ownership of shared information. Companies are concerned on the quality of data, architecture and storage, security and integration, and meta-data models. Data security is mentioned the most, and can be considered as the primary concern.

If other companies extract data from the common cloud, their system security might become an issue.

—Company A

The provider of centralized information platform should also be responsible for data security and access management.

—Company A

Companies trust their own data security, but are concerned of data leaking from the other companies systems. The companies have regulated how products and services are built and sold for a long time, but cybersecurity is a relatively new subject. The technical system chosen for information sharing must allow for case-specific configuration of access control, and security cannot be compromised on.
5.1.3 Cultural Change

Companies report that sharing cross-enterprise data requires a cultural shift towards a coopetition-driven mindset. Different functions in the organization need to be aligned to enable this shift: finance, operations, engineering, design, management and legal. Every function has its own questions and challenges, and the internal discussion is taking a long time before organizations are aligned.

It is a large cultural shift to share data with competitors. The ship is turning really slow. If there would be immediate benefits in sight it would help us move faster.

—Company E

We are moving from a close-minded view towards a more open ecosystem of information utilization.

—Company B

All of the companies have a history of keeping their core intellectual property strictly to themselves, and heavily restricting information that is shared outside of the company. Additionally, the information systems are designed to be used mainly only for the company itself, without support of safe data transactions with near real-time data transferring and access management capabilities.

It is in our culture to build things ourselves. We are afraid of losing competitive edge.

—Company C

The companies consider the cultural impacts of working together with other companies as one of the major changes in their operations, with potentially the greatest benefits as well. New inter-disciplinary processes and roles must be established internally, but also externally to manage the new partnerships.

5.1.4 Identifying Right Information Internally and Externally

As the amount of information collected and stored is increasing, companies find it hard to understand what information they have access to, let alone what information is available in the close ecosystem or value chain around
the company. Understanding information possessed by other companies, and especially the information that could be valuable to the original company, is challenging. Companies report that they would need to have a better understanding of available information especially within the supply chain.

The first step in achieving an efficient information sharing setup is defining the current state of internal information and information needs. In order to identify existing information, both the personnel and information systems must be aligned to provide a holistic view on internal information. The organization might need to close the information loops in order to make sure right people in the right context have access to right information. Only afterwards can the company start identifying external information to support their internal processes, or identify information they possess that can be beneficial to external parties and thus used for transactions.

5.1.5 Common Rules and Operating Model

Companies report that organizing the information sharing with other companies requires the companies to be aligned on what, when and why information is shared, and how the sharing is implemented. The contracts also need to support assigning ownership, responsibilities and rights of the shared information.

We want to better understand creation of value, but also processes and contract models we can utilize in the future.

—Company E

Companies are not certain what kind of contracts are most suitable for the information sharing, and defining the contracts to take all scenarios into account is considered to be challenging. The companies see that information sharing will also require new interdisciplinary processes and roles for each company participating in the setting.

5.1.6 Value Chain Setup

Companies find it hard to understand the value chain of information sharing. How to ensure fairness in the whole setting, when information is more valuable to some companies than others? The main challenge in value chain setup is how can every company benefit from information sharing proportionally to the risk they are taking, as otherwise they would not have entered the information sharing setup in the first place. As every company will prioritize their own gains, finding an equilibrium where every party is satisfied is considered challenging.
We are lacking the understanding of with whom information could be shared, and how we profit from the sharing.

—Company C

Companies need to thoroughly understand their own operations and their internal information availability and external information opportunities, but also which companies can either benefit from their information or have valuable information to give. Understanding how valuable the company’s information is to another company requires deep understanding of the operations of other companies as well.

We have not yet understood the value chain setup and positions of different integration operators.

—Company E

Aside from understanding the ecosystem around information close to the company, the companies must also have an understanding of their position in the value chain. Companies can strive to be either consumers of information, platform providers, providers of information, or a combination of these three.

We need to define a profit model that profits all participants.

—Company B

Finally, companies need to concretely identify and close partnerships with a defined business model where value of shared information is defined. Each company is after their own benefits, but in order to reach an agreement all the parties must benefit.

5.1.7 Sharing Created Value

Every company is incentivised in maximizing the value they receive for sharing the information, but finding a scenario where value sharing is Pareto efficient with sufficient levels across all stakeholders is reported challenging. Companies report that other stakeholders might be able to utilize shared information better by an order of magnitude than the rest. If information related to a single production line is shared, a company operating 500 of these production lines would be able to utilize the information on all of them and tap into a lot of value. According to the companies, this is also something that needs to be taken into account when discussing creation and sharing of value from the information sharing.
There needs to be a win-win scenario: the parties that participate in sharing information must get more benefits than disadvantages. Innovations created from shared information need to benefit all participating stakeholders.

—Company B

This also applies to new innovations coming from the shared information. Companies report that the shared information might lead to innovations that can be very valuable to a subset of companies in the information sharing ecosystem, and the sharing of value from these innovations should be defined beforehand.

5.1.8 Financial Breakeven

Information sharing can be a very resource-intense project, as it essentially requires the alignment of all operations in the company: financial, legal, technical, operational and managerial. With high time and resource requirements to implement the project, financial breakeven can be a lengthy process. Companies report that projects with faster and more obvious financial breakevens are prioritized in the company strategies, and it can be hard to get a project through where the timeline of breakeven is vague.

New initiatives with financial breakeven of more than three years can be forgotten. We are focused on projects that generate profits in less than a year.

—Company E

While companies also need to focus on long-term initiatives with higher risk and reward to maintain their competitive advantage and relevancy in changing ecosystems and value chains, longer breakevens are slowing down the decisions to adopt an information sharing process.

5.1.9 Risk Versus Reward

Companies can quickly see the risks in sharing information, but benefits are more vague. Companies are not motivated by improving the operations of a partner company if it puts them in a risky position without having clear benefits in sight. Every company sees opportunities in gaining access to additional information, but it is unclear who owns inventions created from shared information.
It would help us to proceed faster if we could concretize risks versus rewards. We do not think we can simply share information and figure out the rest afterwards. The risks are easy to understand, while rewards are not.

—Company E

Companies planning to implement information sharing with external partners must understand the entire ecosystem in order to put a value on the information they possess. Even meaningless information to a single company - that could be a side product of something else - might be extremely valuable to another company. If that information is sold for cheap, other companies in the same supply chain might eventually benefit significantly more.

5.1.10 Business Model

The interviewees mention multiple different models that have been discussed for sharing cross-enterprise information in the study setting, such as joint ventures, contracts, platform ecosystem and simply selling information. The companies are not certain which model would be most suitable for different scenarios of information sharing, and consider building a business model around the setting to be difficult.

We see a need for new business models and technologies to further develop our services. Our biggest question related to information sharing currently is how these business models can be defined.

—Company B

Innovating business models internally is difficult, but innovating business models together with external partners, with mutual benefits in mind and with more complexity than a simple transaction, is harder. With financial benefits possibly being vague in the near future, convincing joint partners to change their business processes and invest heavily to systems development is particularly difficult. Effectively sharing information in order for both parties to improve their business while not compromising their competitive advantage is a critical prerequisite to make the risk worth taking. Different business models need to be built based on the level of integration between the stakeholders, with different revenue-sharing mechanisms for different settings.
5.2 Supporting Factors for Cross-Enterprise Information Sharing

All of the companies see potential business benefits of accessing information the other stakeholders possess. For every individual company these perceived benefits were different, ranging from developing their products and services better to rethinking their entire business models and positions in the value chain. While the business impact on the perceived benefits is still vague for many companies, every case company was incentivised to attempt information sharing to a certain extent in order to unveil more value.

5.2.1 Product and Service Development

Information has rapidly transformed how products and services are developed, with the amount of data growing more voluminous and the manufactured products and services more complex. However, working harder and faster on designing products is not sufficient anymore. In order to build competitive advantage, tapping into key information sources and getting the right information to the right people in the right context is crucial. Every company participating in this case study wants to further explore information sharing in order to improve their products and services, with for instance accessing information related to how their products and services are used, or accessing more information on how the entire value chain around their products and services operates.

We want to reinforce our device data with process data to better understand the environment in where our devices operates. If we gain access to this data, we can better understand how our devices and services are used in order to improve them further.

—Company D

In order to match to the demands of global market, companies need to be more integrated and efficient with using information for product and service development. In the context of this study, component providers of the cardboard production line are able to learn how the entire production line works and what are the interdependencies between different providers. With this new information at hand, component providers are able to understand their product performance and cause of errors better, and improve them based on previously unknown data points.
5.2.2 New Business Models

Multiple companies report that they were incentivised to participate in the case study to discover new practices and contract models that they can utilize in the future. Many companies would also like to change their position in the value chain to unlock more value. A few companies report wanting to become a platform provider, enabling other companies to do transactions on a platform they govern, while also tapping into new income flows related to the transactions on the platform.

Transparency of information and shared information platforms enable companies to improve their innovation process and develop new products and services, but also possibly change their position in the entire value chain. In a sharing economy companies essentially state that “What is mine is yours, with a fee”, and there exists multiple companies who operate as connectors in a business ecosystem without owning many assets.

5.2.3 Innovation Process

Companies mention using information more and more as a basis for new innovations, in addition to optimizing their existing operations. With the possibility of accessing key information related to their products or the context where their products are used, the companies are better able to create products with immediate value to end-users. Information sharing allows combining data sources that possibly have not been combined before, such as using performance metrics of valves in order to predict errors in the coating phase later on in the cardboard manufacturing process. As a result, a predictive maintenance system holistically using the input of all components in the production line can be built.

Innovations are often created and found empirically based on customer demand, and such innovations are called end-user innovations. Through information sharing companies can more holistically understand the end-user needs. Research and development functions in the companies can jointly innovative on common shared data, and through joint partnerships and different monetization share created value to all stakeholders proportionally to the contribution. Additionally, a shared information system helps companies identify promising products early in the development process. If companies are able to look at multiple ideas instead of one, they’re going to be better off.
5.2.4 Operational Efficiency

Every company reports more efficient operations as the primary goal of sharing information. In supply chains information sharing leads to more synchronous operations, and the entire value chain can become more efficient. Through linked information management systems, modifications to operations can be incorporated instantaneously when common operating model and rules so allow.

We want to develop our operations as much as possible using information management tools. When a mechanic is on the field, they should have access to all of the information required in a mobile device.

—Company C

The production line operator wishes to reduce production errors in the production line, while the component and information systems wish to gain access to their own products data which the production line operator currently owns, in addition to gaining more information on the whole operation to build better products in the future. Companies see potential benefits in a wide variety of operational efficiencies, ranging from product development to lifecycle management, maintenance, sales and operational efficiency of products and services. In a supply chain, effective information sharing can lead to better utilization of inventory, and expected cost reduction due to optimal production capabilities.

5.2.5 Efficient Partnerships

Many companies view sharing and receiving information to be an important step towards deepening their partnerships. Companies see a lot of synergies across each other, and come up with multiple types of new business models and partnerships that information sharing could lead to, including co-ownerships, consortium, joint ventures, and a platform ecosystem.

Cooperation between all stakeholders is currently too low, and everyone is focusing on their own share of the cake. We need to do changes to our operating models to build stronger partnerships.

—Company C

These partnerships can open up new revenue streams for the companies, but also help them to gain a more holistic understanding of where, how, and with what performance their products and services are currently used to improve their product development and thus competitive advantage.
5.2.6 Technological Viability

Practices related to collecting, storing and sharing information have developed quickly in the participating companies during the recent years. Most companies state that they are performing information sharing already with non-critical information, and challenges are more related to choosing the correct information, ensuring governance of information, and selecting the right business model together with other stakeholders. Companies state they have only recently changed their mindset from owning internal processes and safeguarding their competitive advantage towards identifying external opportunities to guide internal development.

We have only recently understood that we need to be able to combine information from multiple dimensions when developing our products further. Working together with other companies for internal development is a new thing for us.

—Company C

The software for sharing information has developed massively in the recent years, and safely sharing any information is starting to be possible.

—Company B

Technological advancements are the key enabler for this mindset shift. With the availability of data and information and the tools for managing them constantly increasing, companies do not necessarily have to implement custom technology for every use case, but can configure existing software products to their needs, reducing both time and costs. The advantage of building proprietary software is in the possibility to completely customise and target it to unique needs, but the task of maintaining and upgrading the software can be major. With off the shelf solutions the customisation possibilities can be narrower, but it eliminates the need for development and maintenance.

5.3 Action Points for Sharing Information

The action points for information sharing are based on how the interviewees perceive the information sharing process should work. Challenges the companies faced in the case study are covered within the action points, and the prioritization is done according to how the case companies perceive the
importance of individual action points. The action points start with identifying the business opportunity, that can either be related to improving the companies internal processes based on external information, improving existing partnerships with increased information sharing, or selling information for external uses. Then, the next challenges are related to technical implementation, business model, legal setup and processes and roles. The action points are as follows.

1. Identifying business opportunities in three areas: internal operations that can be improved with external information, partnerships that can be developed further by increasing information sharing, or possessed information that is valuable to external parties that can be shared.
2. Defining position in the ecosystem: information producer, information consumer, platform provider, or a combination of the three.
3. Understanding the maturity of information capabilities within the company.
4. Identifying partners around the business opportunities with potential mutual benefits in information sharing.
5. Defining business model, contracts and monetization model of information sharing with the partners to support each parties’ business opportunities.
6. Defining common rules and operational model with the partners to ensure right information is shared at right times only with the right parties.
7. Choosing and building the technology for information sharing that supports sufficient security and efficiency levels.
8. Establishing processes and roles to support sharing of information.

The first action point is crucial in order to set business goals that the company wants to achieve through information sharing. The company needs to have a strong understanding of the internal information streams, opportunities and loops, but also gain a holistic understanding of how valuable their internal information is to external partners. The second action point is all about positioning the company in order to unlock the previously identified business goals. The company can utilize information sharing in varying depths of integration with other companies, from simple transactions to providing a platform or building joint ventures for larger and more transformative business opportunities.
The third action point requires the company to identify technical requirements of information sharing, including features such as access management, security, and defining governance of information. The technology can either be developed internally for more customised solutions, or an external product can be used to reduce maintenance and development costs. The technology must ensure confidential sharing of accurate information in a timid manner.

The fourth action point requires the company to identify partners to share information with. Partners in the same supply chain are the most obvious choice as the companies are already aligned on a common goal in improving the efficiency of the supply chain, but the risks of losing competitive advantage and vertical integration by any party are also higher. The companies can also explore potential partners outside of the supply chains.

The fifth and sixth action points involve defining the information sharing context between the participating companies in terms of business model, common rules, operational model, contract and monetization model. All participating companies have their own business goals in mind before entering the negotiation, and everyone will strive for their individual benefits - yet, mutual benefits need to be obvious for every party in order for the partnership to begin.

Finally, the seventh and eight action points can be done when the partnerships have been agreed upon, and deal with the execution of the information sharing in terms of technology, processes and people involved. When these factors have been agreed on and established, the cross-enterprise information sharing has been defined thoroughly by all parties and can begin.
Chapter 6

Discussion and Conclusions

This chapter is organized as follows. First, main findings and answers to research questions are presented. These results are then tied to existing body of research around the topic of cross-enterprise information sharing, and the contribution and viability of the results are discussed. Finally, potential future research avenues are identified and discussed.

6.1 Main Findings and Answers to Research Questions

The first research question identified barriers related to information sharing: compromising competitive advantage, defining and creating governance of shared information, cultural change towards a coopetitive mindset, identifying right information internally and externally, common rules and operating model, value chain setup, sharing created value between the stakeholders, achieving financial breakeven, balancing risk versus reward, and creating a suitable business model. The barriers can be divided into six categories Khurana et al. defined [17]: managerial, organizational, individual, financial, socio-cultural and technological. Some barriers, such as governance of information, overlap categories. Governance is a technological, financial and managerial challenge, as the technology used in information management and sharing needs to have features such as access management and security; the financial value depends on the level of ownership of information, and the organization needs to define rules for using the information. Figure 6.1 presents a mapping of the identified barriers in cross-enterprise information sharing to the categories presented by Khurana et al.

Companies consider the financial barriers to be most pressing, because initiatives without a clear business objective will not be implemented. Ad-
ditionally, companies are concerned by the unclear business benefits of the risk-versus-reward of information sharing: while they can see internal operational improvements that can be achieved by gaining access to external information, the timeline of financial breakeven can be unclear, and the investment thus hard to justify.

The second research question identified enablers related to information sharing. Companies mainly focused on the internal improvements that can be achieved by gaining access of external information: how the company can improve their products and services, how they can improve innovation process, and how they can transform their business models based on the information they have. The companies also saw potential in improving their partnerships and generating new revenue streams from their information.

The third research question built a set of actions companies should consider implementing before entering a cross-enterprise information sharing setup. The action points start with understanding business opportunities in three areas that can be improved by either buying, selling or trading information with external parties. These areas are internal operations, business partnerships or in the information possessed by the companies. Next, the company needs to define their position in the information ecosystem. They can be either an information producer, participating in selling their information, an information consumer, participating in purchasing information, or a platform provider, providing the ecosystem for other parties to execute information sharing between each other with defined rules, operational model and services, or any combination of these three. Then, the company needs to understand the state of their technological readiness for information sharing, with sufficient information collection and management tools, security, and governance of information required for sharing information. Next, partners need to be concretely identified, common business model, contracts,
monetization model, rules and operational model defined, and the common technology built and configured for the setting. Finally, processes and roles to support information sharing need to be defined.

6.2 Discussion

The identified barriers and supporting factors in cross-enterprise information sharing help companies consider information sharing as a strategic opportunity. Sharing information is not a silver bullet for increased revenue, but through information sharing previously inaccessible value can be created by combining novel information sources. It is challenging to balance the risks versus reward in information sharing, and companies should aim to comprehensively understand the impact of information sharing on their and their partners' businesses prior to building business models and planning monetization. The action points guide companies to consider the different aspects of information sharing, and to help them focus on most important aspects per case. The case companies learned tremendously from attempting to build an information sharing process during the research project, and an experimental project with a selected amount of parties can be suggested as a starting point for companies that are not ready to implement information sharing at scale.

During the time this thesis was written, many relevant initiatives have progressed in the field of information sharing. The Federation of Finnish Technology Industries, a trade and labor market policy organization, has built a package of model contracts for data sharing [36]. The goals of the model contracts are to open up data exploitation for business-to-business negotiations, develop a culture of data agreements, and encourage companies to better identify their own information and to develop partnerships that promote the use of data in business development. The findings of this research are aligned with the need of more refined contract models.

The Finnish Innovation Fund has built a rulebook for fair data-driven business in a network of companies [29]. Figure 6.2 depicts the rulebook’s four distinct stages of utilizing and sharing data. In the first stage the company is utilizing only internal data. In the second stage the company is reinforcing this data with external and open data. In the third stage information sharing between companies occurs, and the network participating in information sharing needs common rules and services. In the final fourth stage services are built on data, and the ecosystem involved in these services needs common services, operating model and rules.

The action points from research question three are necessary for companies to evolve from the first stage to the fourth stage. The transition from
first to second stage requires companies to understand the business opportunities that can be achieved with external data, the action point one. The transition from second to third stage requires companies to define their position in the sharing ecosystem, build partnerships with companies, define rules and operational model in the setup, and build the technical infrastructure for sharing and managing information, the action points two to seven. Finally, the transition from third to fourth stage requires companies to further deepen the common operational model, partnerships and monetization in order to build services from common data that benefit all participating stakeholders.

The findings support the research questions well. Many of the challenges in operational efficiency and product development that the case companies encounter are in line with the benefits achievable through cross-enterprise information sharing. Implementing information sharing requires effort on all levels of the organization and is challenging on many fronts, but can open previously unachievable benefits.

In EU-28 countries 18% of companies over 10 employees are sharing data with their suppliers and customers [39], leaving data an untapped resource for a majority of the companies. In order for systematic development in the society to happen, companies need to be more open to sharing information between each others. The development of artificial intelligence, smart cities, smart transportation and Internet of Things requires compatibility and interoperability of information that is possessed by multiple stakeholders.
6.3 Conclusion

This thesis was motivated by the open issue of “How can companies utilize information possessed by other companies for mutual business benefits“, and the large potential that combining information from multiple sources presents. There exists a lack of related studies with concrete action points guiding companies towards cross-enterprise information sharing. This study investigates how companies can improve their businesses through internal and external information. The research questions address factors supporting and preventing this information sharing, and what actions the companies need to implement in order to tap into the benefits that come with information sharing.

Main challenges and supporting factors in cross-enterprise information sharing are identified, and the results suggest that companies consider information sharing to be a major enabler for their business by improving operational efficiency, level of partnerships, product development and innovation process. However, information sharing can potentially risk the companies competitive advantage typically associated to information only the company possesses. Thus, the risk-versus-reward equation can be unclear for the companies, and information sharing remains an interesting opportunity with an unclear way forward. Additionally, common rules and operational model need to be established support information sharing, value from information sharing accrued between all participating parties, and new business models and value chain setups need to be set. This thesis provides companies a set of actions they need to implement before entering a cross-enterprise information sharing setup. The action points guide companies to establish external partnerships based on their internal goals, and navigate their way in setting the mindset towards coopetition.

The results are in align and can be considered extending the barriers in information sharing by Khurana et al. [17] and challenges in information sharing by Lee [20] by identifying that managers consider sharing created value and governance of shared information to be challenging. The results are aligned with Croom et al. and their finding that technological challenges are just the beginning [5], and with Curry and Moore’s finding that the support of senior management is crucial to build an information sharing culture [6].

Cross-enterprise information sharing is set to change the way that companies think about competition, and open previously unobtainable opportunities. The most logical starting point for information sharing remains in supply chains that are aligned towards a common goal, but companies exploring opportunities outside of their supply chains can also achieve a com-
petitive edge. As the quantity of open information is constantly increasing, companies are already developing systems and technology to utilize external information. As technical solutions, contract models and coopetitive mindset mature, we are entering the next era of information technology — coopetition.

6.4 Future Research Avenues

Sharing information presents multiple new strategic opportunities for companies, such as becoming a platform provider [40] or developing new products and services that haven’t been seen before due to the data they combine. However, a general research on the that potential that large-scale information sharing enables would be valuable.

Technical solutions for building a shared information system need to be researched further to enable better governance of information. The specifications of requirements at different levels of integration in information sharing is crucial so that companies are able to build the technological solutions that provide sufficient level of detail for each case.

Another interesting avenue for further studies is how to value information. While this is a relatively researched topic in supply chains [11] [22], putting a value on information is much more complex to define in companies that do not share the same supply chain.

Common contracts, operating rules and services in information sharing is an avenue that is not well covered in academic research, and the case companies consider this as a main challenge in establishing partnerships. More research is needed in order build a set of model contracts for varying levels of integration between the companies, from simple transactions to more integrated operations with continuous information sharing.
Bibliography


# Appendix A

## Interview Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Text</th>
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</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>What is your name, company and position?</td>
</tr>
<tr>
<td>Question 2</td>
<td>What do you do daily?</td>
</tr>
<tr>
<td>Question 3</td>
<td>What data are you providing to the common cloud?</td>
</tr>
<tr>
<td>Question 4</td>
<td>How and where is the data created?</td>
</tr>
<tr>
<td>Question 5</td>
<td>Describe the architecture of the common cloud.</td>
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<tr>
<td>Question 6</td>
<td>How is your company contributing to the common cloud?</td>
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<tr>
<td>Question 7</td>
<td>What factors in your organization prevent sharing data and why?</td>
</tr>
<tr>
<td>Question 8</td>
<td>Who is the deciding party of these factors?</td>
</tr>
<tr>
<td>Question 9</td>
<td>What institutional blocks do you see affecting the venture?</td>
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<tr>
<td>Question 10</td>
<td>Have you been trying to get rid of the barriers in this project? How could this be done?</td>
</tr>
<tr>
<td>Question 11</td>
<td>Why has this venture not been implemented before?</td>
</tr>
<tr>
<td>Question 12</td>
<td>What business goals do you have regarding this venture?</td>
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<tr>
<td>Question 13</td>
<td>What would access to the common data enable to your organization?</td>
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<tr>
<td>Question 14</td>
<td>How will the shared data change your current business?</td>
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<tr>
<td>Question 15</td>
<td>Describe how you understand data quality.</td>
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<tr>
<td>Question 16</td>
<td>What criterias do you have regarding data quality?</td>
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<tr>
<td>Question 17</td>
<td>How do you maintain data integrity for the data you provide to the system?</td>
</tr>
<tr>
<td>Question 18</td>
<td>If the quality and governance of data improved, how would it benefit your organization?</td>
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<tr>
<td>Question 19</td>
<td>How and when is data inserted into the common cloud?</td>
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<tr>
<td>Question 20</td>
<td>What are the data flows in the system?</td>
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<tr>
<td>Question 21</td>
<td>Should your data be deleted if you wish to leave the collaboration?</td>
</tr>
<tr>
<td>Question 22</td>
<td>Who should be allowed access to which data?</td>
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<tr>
<td>Question 23</td>
<td>What about subsets of the data? For example averages over time?</td>
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<tr>
<td>Question 24</td>
<td>Do you have criterias regarding the security of data?</td>
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<tr>
<td>Question 25</td>
<td>What concerns do you regarding security of the data?</td>
</tr>
<tr>
<td>Question 26</td>
<td>What concerns do you regarding security of the data?</td>
</tr>
<tr>
<td>Question 27</td>
<td>Is any of the data shared outside of the local network?</td>
</tr>
<tr>
<td>Question 28</td>
<td>If so, with what policies is the data shared to third partie</td>
</tr>
<tr>
<td>Question 29</td>
<td>How do you understand data ownership?</td>
</tr>
<tr>
<td>Question 30</td>
<td>Who do you trust with the data, and why</td>
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<tr>
<td>Question 31</td>
<td>Describe the policies you have regarding data ownership.</td>
</tr>
<tr>
<td>Question 32</td>
<td>What criterias do you have regarding data ownership?</td>
</tr>
<tr>
<td>Question 33</td>
<td>What concerns do you have regarding data ownership?</td>
</tr>
<tr>
<td>Question 34</td>
<td>What negotiations must be done to go forward with the current venture?</td>
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<tr>
<td>Question 35</td>
<td>In what kind of business initiatives would you be interested in regarding the shared data?</td>
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<tr>
<td>Question 36</td>
<td>If new business initiatives were created from the data, how would you like to participate?</td>
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<tr>
<td>Question 37</td>
<td>Do you have experience with cross-licensing models?</td>
</tr>
<tr>
<td>Question 38</td>
<td>Have you formed cross-licensing contracts prior to or in the context of this project?</td>
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<tr>
<td>Question 39</td>
<td>What sections do these contracts contain?</td>
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<tr>
<td>Question 40</td>
<td>Have you formed cross-licensing contracts prior to or in the context of this project?</td>
</tr>
<tr>
<td>Question 41</td>
<td>Do you have experience with joint ventures? Do you see potential in this context?</td>
</tr>
<tr>
<td>Question 42</td>
<td>Are there any regulatory considerations regarding this venture?</td>
</tr>
<tr>
<td>Question 43</td>
<td>What kind of business model would be the best suitable for this venture? What are the different parts or options?</td>
</tr>
<tr>
<td>Question 44</td>
<td>Is there something I should have asked you?</td>
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</table>