Aalto University
School of Science
Degree Programme in Industrial Engineering and Management

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Utilizing Cross-Enterprise Data of Production Lines:
A Case Study

Master's Thesis
Espoo, June 18, 2016

DRAFT! — July 11, 2017 — DRAFT!

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ABSTRACT OF MASTER'S THESIS

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Due to the sophistication of IT in the recent decades, collecting data from physical products and production lines has become an opportunity for many industries. This data is set to change business models in many organizations, such as by enabling cutting middlemen and allowing providing of products-as-a-service. In this study, a cross-enterprise data network of four organizations operating in forest industry is presented. The research objective is to identify new business opportunities enabled by shared real-time data. The focus is on a single production line, where sensor data from machines is collected and opened for all stakeholders. As a result, ..

Keywords:	ocean, sea, marine, ocean mammal, marine mammal, whales, cetaceans, dolphins, porpoises
Language:	English

Aalto-yliopisto
Perustieteiden korkeakoulu
Tietotekniikan koulutusohjelma

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Kivi on materiaali, joka muodostuu mineraaleista ja luokitellaan mineraalisisältönsä mukaan. Kivet luokitellaan yleensä ne muodostaneiden prosessien mukaan magmakiviin, sedimenttikiviin ja metamorfisiin kiviin. Magmakivet ovat muodostuneet kiteytyneestä magmasta, sedimenttikivet vanhempien kivilajien rapautuessa ja muodostaessa iskostuneita yhdisteitä, metamorfiset kivet taas kun magma- ja sedimenttikivet joutuvat syvällä maan kuoressa lämpötilan ja kovan paineen alaiseksi.

Kivi on epäorgaaninen eli elottoman luonnon aine, mikä tarkoittaa ettei se sisällä hiiltä tai muita elollisen orgaanisen luonnon aineita. Niinpä kivestä tehdyt esineet säilyvät maaperässä tuhansien vuosien ajan mätänemättä. Kun orgaaninen materiaali jättää jälkensä kiveen, tulos tunnetaan nimellä fossiili.

Suomen peruskallio on suurimmaksi osaksi graniittia, gneissiä ja Kaakkois-Suomessa rapakiveä.

Kiveä käytetään teollisuudessa moniin eri tarkoituksiin, kuten keittiötasoihin. Kivi on materiaalina kalliimpaa mutta kestävämpää kuin esimerkiksi puu.

Asiasanat:	AEL, aineistot, aitta, akustiikka, Alankomaat, aluerakentaminen, Anttolanhovi, Arcada, ArchiCad, arkki
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Lilla Vargens universum är det tredje fiktiva universumet inom huvudfåran av de tecknade disneyserierna - de övriga två är Kalle Ankas och Musse Piggs universum. Figurerna runt Lilla Vargen kommer huvudsakligen från tre källor — dels persongalleriet i kortfilmen Tre små grisar från 1933 och dess uppföljare, dels långfilmen Sången om Södern från 1946, och dels från episoden "Bongo" i långfilmen Pank och fågelfri från 1947. Framför allt de två första har sedermera även kommit att leva vidare, utvidgas och införlivas i varandra genom tecknade serier, främst sådana producerade av Western Publishing för amerikanska Disneytidningar under åren 1945–1984.

Världen runt Lilla Vargen är, i jämförelse med den runt Kalle Anka eller Musse Pigg, inte helt enhetlig, vilket bland annat märks i Bror Björns skiftande personlighet. Den har även varit betydligt mer öppen för influenser från andra Disneyvärldar, inte minst de tecknade långfilmerna. Ytterligare en skillnad är att varelserna i vargserierna förefaller stå närmare sina förebilder inom den verkliga djurvärlden. Att vargen Zeke vill äta upp grisen Bror Duktig är till exempel ett ständigt återkommande tema, men om katten Svarte Petter skulle få för sig att äta upp musen Musse Pigg skulle detta antagligen höja ett och annat ögonbryn bland läsarna.

Nyckelord:	omsättning, kassaflöde, värdepappersmarknadslagen, yrkesutövare, intresseföretag, verifieringskedja
Språk:	Engelska

Chapter 1

Acknowledgements

I wish to thank all students who use LaTeX for formatting their theses, because theses formatted with LaTeX are just so nice.

Thank you, and keep up the good work!

Espoo, June 18, 2016

Olli Rissanen

Abbreviations and Acronyms

Data governance	Defines applicable rights and duties, provides corresponding methods and tools
3GPP	3rd Generation Partnership Project
ESP	Encapsulating Security Payload; An IPsec security protocol
FLUTE	The File Delivery over Unidirectional Transport protocol
e.g.	for example (do not list here this kind of common acronymbs or abbreviations, but only those that are essential for understanding the content of your thesis.
note	Note also, that this list is not compulsory, and should be omitted if you have only few abbreviations

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Definitions

Chapter 5

Introduction

5.0.1 Research Motivation

The survival of enterprises is more and more dependant on the way they collect, use and share data. With the development of information and communication technology, sharing data between supply chains has improved the competitive advantages of all of the parties. However, there still exists a lack of information that would allow companies to better develop their products, coordinate actions and serve their customers. This information is most often held by another enterprise, possibly in another supply chain, who is not willing to share it due to losing some of the companys competitive advantage. Balancing between competition and cooperation - coopetition - is becoming an increasing trend within the industry and academica []. This study aims to identify the factors that prevent and support sharing data between enterprises, in an attempt to create an environment most suitable for sharing data and thus improving organizational efficiency.

The role of knowledge as a vital enabler for competitive differentiation has been emphasized since Penrose, 1995 [**?**]. Knowledge sharing processes across organizational boundaries have recently been investigated by multiple academics [**?** **?** **?**]. The strategic paradox between protecting and sharing knowledge suggests that a need exists for new approaches that reconcile intra- and inter-organizational knowledge sharing.

Supply chain is defined as a system of enterprises with different roles where material, financial and information flows to both directions [**?**]. The external sources are of great importance to the supply chain participants, as companies need both internal and external sources to create value. However, digitisation disrupted every link in the value chain [**?**]. 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 processes, communication and eventually transforming business models.

Horizontal collaboration in an supply chain [] is the sharing of assets between competitors for mutual benefits. Operating in this manner, companies decide to cooperate to improve the business for both of the parties. An example of such an scenario would be manufacturing companies that share knowledge on common production deficencies to optimate the utilization of their machinery. While it might take a single company a long time to investigate reasons for certain production deficencies, combining information and knowledge cross-enterprise would eventually help both parties. If the companies are able to collaboratively optimize everything, the collaboration achives efficiencies and benefits beyond what either company can achieve on its own. However, balancing the situation is tricky. A deal for a company is only a better deal if it doesn't help a competitor more than it does the company. From an information sharing perspective, quantifying benefits is often hard. Sharing information requires careful strategic consideration as to the operational implications to ensure success. Technical advancements have made sharing information quicker and cheaper than ever before, and factors to consider instead deal with strategic and operational matters. The open issues companies face when considering sharing cross-enterprise include profit sharing models, contracts, [].

5.0.2 Research Questions, Goal and Scope

What kind of an environment supports sharing cross-enterprise data between a manufacturer and its supply chain partners?

RQ1: What factors prevent sharing data in this study setting? This research question aims to identify and categorize the obstacles that affect sharing different types of data between companies. This research question builds on the barriers identified in supply chain integration. TODO:fix lastsentence. The question is answered by interviewing companies participating to the research project.

RQ2: What factors support sharing data in this study setting? After the key factors that prevent sharing data have been identified and categorized, this research question aims to identify a business setting suitable for each parties aknowledging their criterias and needs.

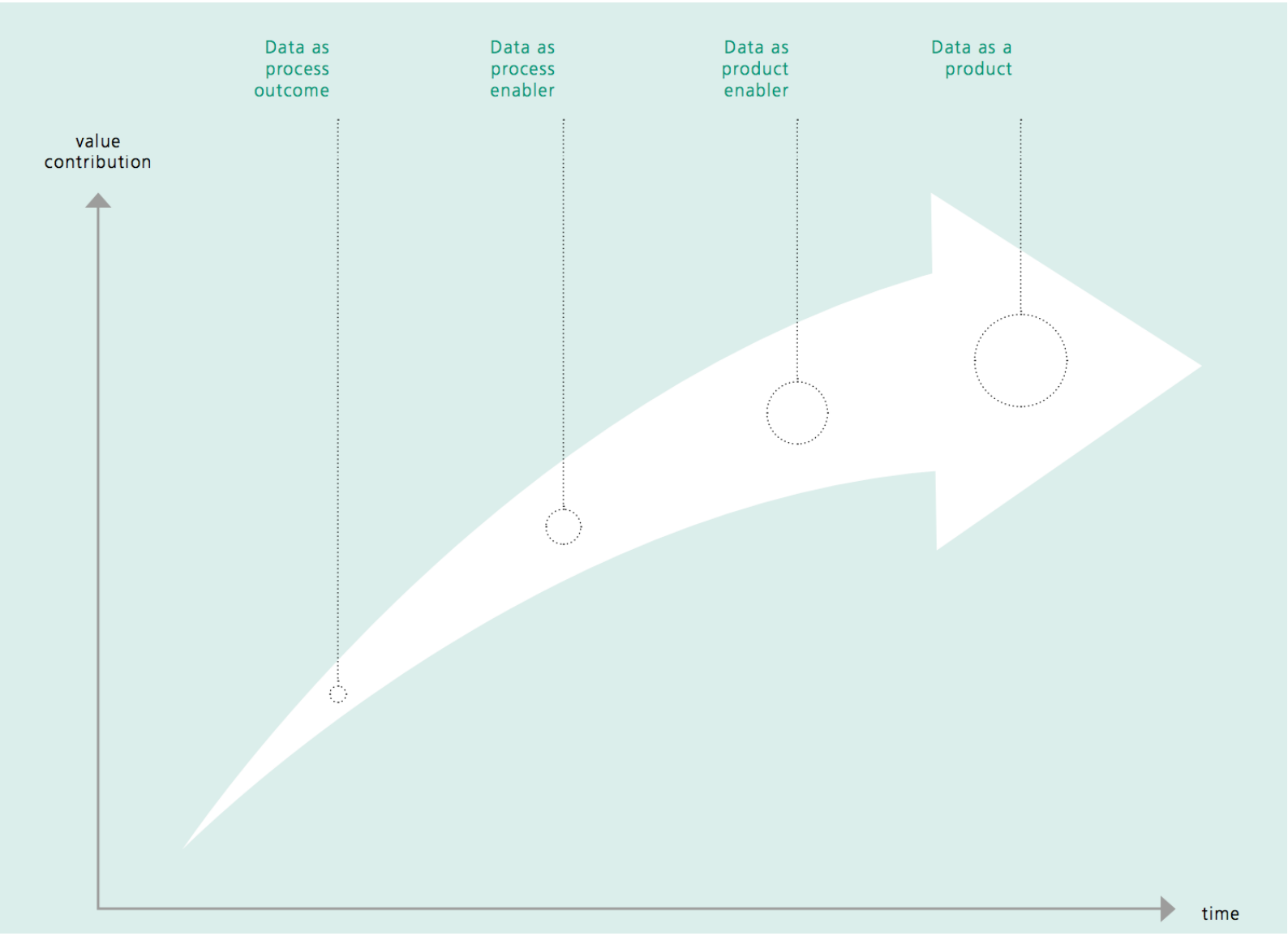
5.0.3 Research Methods and Data

The empirical part of this case study is done in the context of research project between a paper mill operator and its supply chain partners. Operational data by the paper mill operator is shared between the component providers and a maintenance service provider in an attempt to improve the operational efficiency of the mill by utilizing cross-enterprise information, knowledge and capabilities. The mill operator has ownership of the operational data from the components, which is shared through providing access to a private server. However, it is unclear for the participating companies how to continue the cooperation after the initial research project. As part of the research project the companies signed non-disclosure agreements, which prevent leaking information outside the setting, but do not have contracts as for how to share potential profits. The key motivator of sharing data for companies is to ensure they benefit more than they lose.

The theory of this study builds on top of supply chain management and information sharing in supply chains, knowledge sharing, and platforms. For namely [**?**] which studies information transfer models, [**?**] which identifies willingness and connectivity as the key dimensions to information sharing, and [] that studies the common barriers in information sharing. TODO: platform tanne!

TODO: yritysten tavoitteet tulevaisuudessa

5.0.4 Outline of the Thesis



Marketplace:

[**?**] Centralized data marketplace: platform operator provides facilitation services through technical platform

"centralized design can only work as long as its facilitation services result in it being preferable to users compared to repeated bilateral exchanges in terms of cost, reach of suppliers, speed, and so on"

Decentralized data marketplace: structural elements no longer offered by the centralized platform, but executed by data participants.

exhaust data: created as a by-product of other activities such as socializing, rather than specifically for analytical purpose

[**?**] marketplaces for trading data with varying licensing models

5.1 Structure of the Thesis

This thesis is structured as follows. In the third chapter, the relevant literature in operations management, maintenance operations management, shared enterprise data and industrial internet are studied to both educate the reader on the subject and to position this study in the field.

Chapter 6

Research Design

6.0.1 Case Study

Case study is a way to collect data through observation and to test theories in an unmodified setting. The linkage with empirical evidence makes case study research likely to have strengths such as novelty, testability and empirical validity [**?**]. Case studies can be divided into four different purposes: Exploratory, Descriptive, Explanatory and Improving [**?**]. An exploratory case study seeks new insights, finds out what is happening, and generates ideas and hypotheses for new research. Descriptive case study attempts to portray a situation or a phenomenom. An explanatory case study attempts to seek an explanation to a problem or a situation, mostly in a causal relationship. Finally, an improving case study tries to improve an aspect of the studied phenomenom.

Different approaches to the order of data collection, analysis and generalization can be categorized into inductive, deductive and abductive approaches [**?**]. An inductive approach moves from data to theory, and begins by first collecting the data, and then looking for patterns and forming theories that explain those patterns. A deductive approach is in reverse order. An abductive approach starts with the consideration of facts or particular observations, which are then used to form hypotheses that relate them to a fact or a rule that accounts for them. The facts are therefore correlated into a more general description, that relates them to a wider context.

Sampling

Structure [**?**]

Triangulation

This study is an exploratory inductive study,

6.0.2 Qualitative research

6.0.2.1 Data collection

The interview is a semi-structured interview with a standardized set of open-ended questions, which allows deep exploration of studied objects. The interviews are performed once per interviewee, with one two two interviewees per participating company.

6.0.2.2 Data analysis

Data analysis is based on template analysis, which is a way to thematically organize and analyze qualitative data [**?**].

Chapter 7

Theory

The relevant literature and theories are organised into two sections: barriers and supporting factors of sharing data. The barriers utilize literature from informatics in supply chains, knowledge sharing and institutional theory. The supporting factors consider existing models where data sharing has been enabled, or models that plan such activies in terms of roles, processes, ..

7.0.3 Barriers in sharing inter-enterprise data

The theoretical background for inter-enterprise data sharing is comprised of literature on inter-enterprise knowledge sharing, supply chains,

The barriers

Sharing data between operators in a single supply chain is a widely studied subject in academia, with researchers pondering on topics such as barriers to information sharing [**?**], global knowledge sharing [**?**] and information sharing [**?**]. Khurana et al. divide barriers to information sharing into six different categories: managerial, organizational, individual, financial, social and cultural. Crucial barriers identified are the financial, technological and organizational barriers for integration of information sharing with supply chain. The barrier with the highest importance is financial constraint for high cost of maintenance, followed by data and information security. The following figure lists identified barriers by category.

Table 1: List of main criteria and sub criteria for barriers for information sharing

Main criterion	Criterion code	Sub criterion
Managerial barriers	MB 1	Lack of perceived benefits of inform
	MB 2	Lack of trust and of confidence in in
	MB 3	Lack of leadership and managerial
	MB 4	Conservative business practices
	MB 5	Lack of accuracy and credibility of i
	MB 6	Opportunistic behavior of the chain
	MB 7	Undefined roles and responsibilities
	MB 8	Poor Targeting of Information
Organizational barriers	OB 1	Poor infrastructural facilities for in
	OB 2	Fear of losing company stability an
	OB 3	Lack of top management support
	OB 4	Formal rules, guidelines and proced
	OB 5	Centralization of hierarchical structu
	OB 6	Lack of long-term relationship amo
	OB 7	Lack of corporate culture for inform
Financial barriers	FB 1	Lack of resources for system design
	FB 2	Lack of resources for cost of hardwa
	FB 3	Lack of resources for software cost
	FB 4	Lack of resources for operational ex
	FB 5	Financial constraints for high cost o
	FB 6	Cost of specialized manpower and t
Technological barriers	TB 1	Data and information Security
	TB 2	Incompatibility of information syste
	TB 3	Lack of technical support for mainte
	TB 4	Lack of efficiency and effectiveness
	TB 5	Sophisticated and complex technolo
	TB 6	Rapidly changing technology
Individual barriers	IB 1	Fear of penalty if the shared inform
	IB 2	Reluctance by unsatisfied individua
	IB 3	Fear of loss of intellectual property
	IB 4	Fear of embarrassment for sharing i
	IB 5	Information overload for gathering
	IB 6	Lack of rewards and incentives for i
Social-cultural barriers	SCB 1	Different values, cultural and lingu
	SCB 2	Lack of computer literacy among st
	SCB 3	Lack of support, encouragement mo
	SCB 4	Employee with diverse missions, go
	SCB 5	Lack of commitment/involvement of
	SCB 6	Difference in levels of education, sk
	SCB 7	Lack of willingness and sharing spi

Loebecke et al. have studied the strategic paradox of protecting versus sharing knowledge between organizations [**?**]. 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 [**?**], 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.

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 [**?**]. Another issue is managing the coordination between organizations, and preventing individuals from leaking private information into the public domain.

managerial: "do not realize the benefits of information sharing " "do not have confidence in information sharing system" "lack of training and experience and low literacy about new technology"

¡kuva¿

Co-opetition and knowledge transfer -

Managing inter-organizational knowledge sharing

chiu2006understanding

7.0.3.1 Institutional Theory

7.0.4 Supporting factors for sharing data

The contents and procedures for knowledge transfer are specified in comprehensive contracts [**?**].

In inter-organizational tacit knowledge sharing, prior research proposes group modes of coordinating work [**?**].

Role concept: https://www.fraunhofer.de/content/dam/zv/en/fields-of-research/industrial-data-space/whitepaper-industrial-data-space-eng.pdf Data provider Data user

7.0.4.1 Data Governance

Data governance is a set of practices that ensures data assets are managed comprehensively within an organization.

Difference between governance and management can be differentiated as follows [**?**]: 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.

IT assets and and information assets can also be differentiated [**?**]: 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.

Data governance can be divided into nine different management functions[**?**]:

- 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 operations -
- Data development
- Data security
- Data development
- Data security
- Reference and master data

- Data warehousing and business inteligence
- Document and content
- Meta-data

Four management functions, namely

data lifecycle management, data quality, data security and access management -ensure approppriate use of data by appropriate stakeholders

data ownership (provenance) -who are accountable for quality and security of critical data -what ownership actually means -define the rights and responsibilities of owners -indicate whether and how those responsibilities change over time

7.0.4.2 Extended Enterprise

Extended enterprise is a term created by Chrysler, originally used to define businesses with an extended global supply chain of thousands of suppliers and distributors [**?**]. Another definition is "the entire set of collaborating companies both upstream and downstream, from raw materials to end-use consumption, that work together to bring value to the marketplace" [**?**].

The problem areas extended enterprises often deal with consist of business process integrations and time-cost reductions.

Recently, a knowledge-based view of the extended enterprise model has been created [**?**]. This model takes into account recent research in supply-chain management, operations, strategy and innovation.

7.0.4.3 Business models

New Service-provider and Business-model Disruption in the Industrial Internet of Things (IIoT) https://www.iiconsortium.org/news/joi-articles/2016-June-New-Service-provider-and-Business-model-Disruption-in-the-Industrial-Internet-of-Things.pdf

Chapter 8

Background

8.0.5 Case description

Stora Enso operates a mill in Imatra, Finland, that produces cardboard. A single cardboard machine, namely the cardboard machine 5, was chosen as the topic of this research project. The cardboard machine consists of components from multiple manufacturers, such as valves, automation system and motors. The cardboard machine 5 produces liquid packaging cardboard, that consists of three unique layers.

The companies participating to the research project are Stora Enso, three component providers: ABB, Metso and Valmet, and Efora, which is the maintenance service provider. Stora Enso provides the data from the component providers machines, that it owns due to having bought the machines, to all of the participants. For the sake of securing operational data from Stora Enso and the participating organizations, only data used in producing the outer layer is shared.

8.0.6 Maintenance view

8.0.7 Information systems

8.0.7.1 Data models

Chapter 9

Findings and Analysis

9.0.8 Barriers

1. Not sure which parties to include 2. Afraid of losing competitive advantage: -Does coopetition beat competition? -How to balance own advantage? 3. Understanding. What data, to whom, why, how? 4. Historical and cultural barriers 5. Lacking practices and contract models

9.0.9 Support

1. Business opportunities: which, what, how?

2. Technological advancements has made sharing data possible 3. Whole society moving to this direction 4. More business opportunities

TODO: tuo google drivesta lÃ¶ydÃ¶kset

Chapter 10

Discussion and Conclusions

10.0.10 Main Findings and Answers to Research Questions

10.0.11 Contribution and Implications

10.0.12 Avenues for further research

10.0.13 Conclusion

Bibliography

Appendix A

First appendix

This is the first appendix. You could put some test images or verbose data in an appendix, if there is too much data to fit in the actual text nicely.

For now, the Aalto logo variants are shown in Figure A.1.

(a) In English

(b) Suomeksi

(c) På svenska

Figure A.1: Aalto logo variants