NTNU
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Future Value chains

Additive manufacturing and Shared Value
Creation

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Preface

This thesis was conducted at the Norwegian University of Science and Technology, at the department of Industrial Economy and Technology Management. The thesis is written in context of the strategic purchasing specialization course in the Global Manufacturing Management master program.

The thesis is written for SISVI – Sustainable Innovation and Shared Value Creation in Norwegian Industry. The aim of the thesis is to contribute to SISVI by exploring additive manufacturing's impact on competitiveness in future value chains, and how one may interact in networks to implement the technology with the aim to create shared value.

I would like to thank my supervisor, Luitzen De Boer for all the help with finishing this thesis by guiding and commenting on my work. Additionally, I would like to thank my co-supervisor, Michael Myrvold Jenssen who have been a great support in discussing my thesis and providing inspiration and support throughout the writing process. I would also like to express gratitude towards Plasto AS, and especially Runar Stenerud and Lars Stenerud who have provided me with crucial and interesting data.

Kristiansand 28.05.2017

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Abstract

The aim of this thesis is to explore the value chains of the future by examining use and implementation of novel technology. Environmental and social considerations will be essential in planning future value chains, thus it's crucial that innovation and technological development of products and processes reflect this. The handling of environmental and social issues in the future is examined through a framework called Shared Value Creation (SVC), that aims to tackle these challenges, while also providing opportunity for business to create financial sustainability. Additive manufacturing (AM) is chosen as the technology to be examined due to its novelty and popularity in both the private sphere and for industrial uses. Layered manufacturing technology can manufacture parts with a variety of characteristics that traditional manufacturing methods cannot achieve. However, the implementation of AM is difficult due to the variety of knowledge needed to utilize it to its full extent. To assess the implications that implementing AM may have on value chains, it is thus important to explore how an organization can best position themselves to gain the necessary knowledge. A possible solution is to utilize an organization's industrial network by interacting with actors and access external resources. A case study is performed on a company who has successfully utilized AM to improve one of their products. The company is analysed based on their participation in a development project, considering three main topics, namely additive manufacturing, interactions and shared value creation. These topics are comprised into a conceptual framework that assess how an organization can implement AM by interacting with actors in the industrial network, and what impact AM has on the value chain with regard to environmental, social and financial sustainability. The result of the research showed that interactions played a crucial part in enabling AM implementation, in that the case company coordinated resources with network actors, which resulted in creation of new knowledge related to AM. Furthermore, the outcome of the development project proved to be beneficial in a SVC perspective, which may indicate that AM can support competitiveness in future value chains.

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Abbreviations

3D-CAD	3D Computer Aided Design
3DP	3D-Printing, a layered manufacturing technology
AM	Additive Manufacturing
AMF	Additive Manufacturing File Format
CAD	Computer Aided Design
EC	European Commission
E-CAM	E-commercial Channels for Additive Manufacturing
ESVC	Ecosystem of Shared Value Creation
IC2	Intelligent and Customized Tooling, a research project.
Interactions	Activities between actors to access external resources
MTO	Make to Order
RM	Rapid Manufacturing
RT	Rapid Tooling
RP	Rapid Prototyping
SCM	Supply Chain Management
SSCM	Sustainable Supply Chain Management
SLS	Selective Laser Sintering, a layered manufacturing technology
SRM	SINTEF Raufoss Manufacturing AS
STL	Stereolithography
SVC	Shared Value Creation

1 Introduction

“Value chains of the future” explore technology and notions about how value chains will or should look like in future Norwegian industry. The Norwegian government plans to be aggressive in its policies to change the industrial landscape in Norway towards a focus on green competitiveness (Nærings- og fiskeridepartementet, 2017). This entails that social, environmental and financial sustainability will be more significant in the future, thus putting pressure on designing value chains that supports these aspects. Technology has a particular role in the future of Norwegian industry due to its ability to reduce the importance of labour cost through for example automation. Technology may also enable organizations to incorporate social and environmental considerations into their strategies and broaden the scope of value chain productivity beyond profits.

The thesis is exploring possibilities for sustainability in future value chains, aiming to contribute to SISVI (Sustainable Innovation and Shared Value Creation in Norwegian Industry). SISVI is a research project where NTNU and SINTEF Raufoss Manufacturing AS cooperate with industry partners to achieve project goals, which includes sustainability and shared value creation. SISVI was started in May 2014 and will end in May 2018. The project is 80 % funded through Forskningsrådets brukerstyrte innovasjonsarena and 20 % by the participating companies. The overarching goal of SISVI is to create competitiveness in Norwegian industry through sustainability and shared value in line with the Norwegian government’s vision for the future. To this end, industry partners aim to implementing strategies and business models based on research that supports sustainability and shared value creation into their organizations. To contribute to this, the thesis focuses on impacts innovative technology, namely additive manufacturing may have on the value chain in the perspective of creating value that benefit environment and society.

The topic of this thesis is additive manufacturing (AM) and shared value creation (SVC). Additive manufacturing is an emerging process that utilizes layered manufacturing technology to create complete parts. Due to the novelty of the technology, it is not widely used in large scale production, and most literature on the subject focus on layered manufacturing technologies in isolation (Berman, 2013; Huang, Liu, Mokasdar, & Hou, 2012). Conversely, this thesis approach AM as a process and focus on barriers to implement the technology and how an organization may overcome these.

Shared value creation is a framework outlined by Michael E. Porter and Mark R. Kramer (2011), focusing on businesses creating value by incorporating social and environmental issues into their strategies. The framework is a response to a perceived divide between society and business that promotes an unhealthy opposition. In essence, the framework encourages making products that benefit society and improving activities in the value chain to raise productivity. It builds on the notion that businesses are more effective than governments at achieving productivity, and that by redefining the meaning of productivity to include environmental and social measures, the divide between business and society can be diminished (Porter & Kramer, 2011).

There are indications that AM can enable the creation of shared value by providing new dimensions to production through the characteristics layered manufacturing technology provides (Sletfjerding, 2016). However, barriers to implementing AM pose a challenge to organizations, which complicates the possibility to take advantage of these characteristics. The practical challenges to utilize AM are connected to cost, quality, knowledge etc. To use AM as an enabler of SVC one needs to overcome the barriers and circumvent the limitations of the technology. This thesis expects that this problem can be solved by cooperation with other actors i.e. engaging in technological development through network activities (Håkansson, 1987). Since we regard AM as a process, there are various aspects that needs to be considered, from conceptualization of part, to manufacturing the finished part. Regarding the implementation of AM, interactions may be used to facilitate technological development and thus potentially enable AM to be introduced into an organization’s value chain to create shared value.

2 Background and research questions

The thesis consists of three topics, namely additive manufacturing (AM), interactions and shared value creation (SVC). The aspect of AM that is to be researched is how it can be implemented to enable SVC. However, there are barriers connected to implementing AM in an organization. First, AM consists of costly machines and materials. Second, AM requires a spectrum of skills and capabilities such as knowledge of materials, skills in traditional manufacturing, machining and design capabilities, which may or may not be present in an organization. To overcome these barriers the organization must innovate their processes by accessing new knowledge and resources. These resources might be found with other actors in the organization's industrial network and accessed through interactions. Interactions in this regard, refers to the transfer and combining of knowledge between actors in an industrial network through cooperation (Håkansson, 1987).

Literature refer to innovative capability as a criteria to be sustainable (Pagell & Wu, 2009). This is not explicitly mentioned as a prerequisite for SVC, but some of the aspects of the framework indicate innovative capability's importance. For example, SVC puts emphasis on redefining productivity in the value chain to reduce environmental and social harm from an organization's activities (Porter & Kramer, 2011). Dynamic capabilities helps define innovative capabilities by focusing on creating value and competitiveness in rapidly changing business environments through recombining skills, resources and competences to fit the changing markets (Teece, Pisano, & Shuen, 1997). AM is an emerging technology that are used in different industries for a variety of purposes (Huang et al., 2012). However, implementing AM to create shared value will require an innovative capability due to organizational processes needs to be altered to fit the new technology (Teece et al., 1997). Consequently, to create shared value through AM, it is reasonable to believe that an organization must develop new capabilities through coordinating activities that recombines resources and alters processes. One facet of the SVC framework is the enabling of cooperation between actors such as industrial partners, governments, NGOs and society, and this interaction may be a point of departure in fostering innovative capabilities.

Based on this, innovation is illustrated through the concept of interactions, which concerns various levels of cooperation and knowledge transfer between actors in industrial networks (Håkansson, 1987). To assess interactions, a framework for technological development in networks is applied. The arguments for why technological development appears in networks are based on firms interacting with different actors to create new knowledge. Based on the arguments above, two hypotheses are created:

Hypothesis 1: Interactions are necessary to be able to use AM effectively because there is a need for a variety of new skills and capabilities.

Hypothesis 2: The use of AM can induce SVC through the benefits this technology provides.

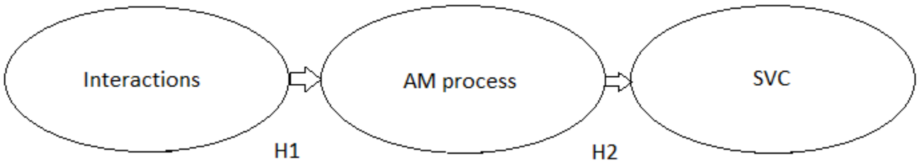

Figure 2.1 Hypotheses

Figure 2.1 is a representation of the hypotheses and how the three elements of this thesis are connected. The arrows describe a path that starts with interactions, which enables implementation of AM, that may lead to SVC.

These hypotheses lay the foundation for the research questions.

AM is not a separate technology, but a process that utilizes layered manufacturing technologies such as 3D-printing (3DP) to create a finished product (Gibson, Rosen, & Stucker, 2015). The capabilities/skills a company should possess to make sound use of AM extends beyond the understanding of 3DP technology, which may pose a challenge. One possibility to solve this problem is to source needed skill and capabilities elsewhere by accessing external resources through interactions in industrial networks. In addition to viewing buyers and suppliers as part of the industrial network, the thesis also considers non-traditional actors such as governmental institutions as possible interaction partners.

Question 1: Can interactions with actors in an organization’s industrial network support clarifying and overcoming the barriers of implementing AM?

Theoretically, AM can prove useful for SVC purposes (Sletfjerding, 2016). However, AM technology has limitations as well as benefits that could offset the creation of value. This notion is explored further through a practical approach.

Question 2: Which benefits does AM provide in a shared value perspective?

The third research question relates to the SISVI project and concerns competitiveness. The main intention of the thesis is to examine if the use of AM to create shared value will lead to a more competitive business. This question is derived from the notion that SVC is an important part of building competitiveness in the future (Fet & Jenssen, 2014; Porter & Kramer, 2011).

Question 3: Are there indications that AM is beneficial for the case company in terms of creating shared value, and thus competitiveness?

Figure 2.2 illustrate the research questions and their relation to each other. Question 1 and 2 connects interactions, AM and SVC and are considered in the context of the case company. Question 3 aims at contributing to SISVI by viewing the topics in conjunction and assessing AM's overall impact on competitiveness in SISVI's context.

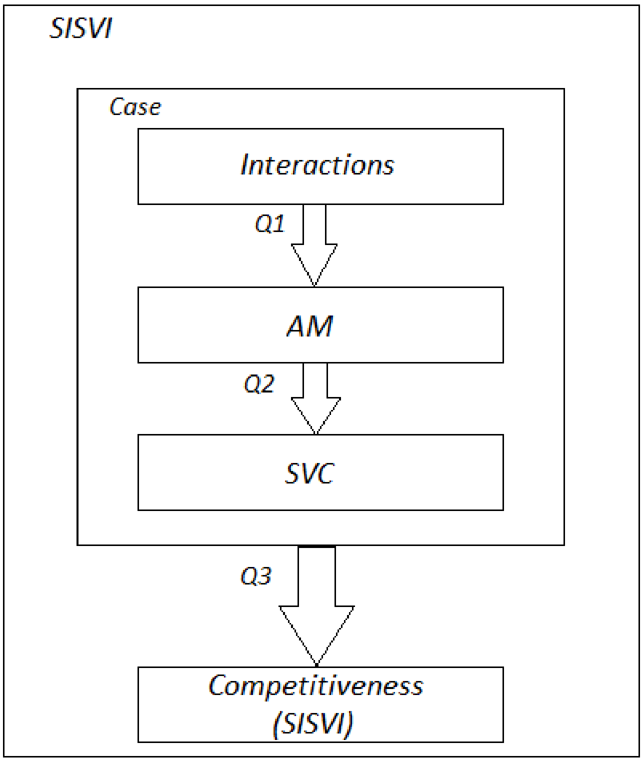

Figure 2.2 Research questions

3 Research Method

The following chapter outlines the research method, including collection of literature and the approach to applying this to a real-world context.

3.1 Research questions and hypothesis

Due to the nature of the research questions, that is, seeking a deeper understanding of the topics and how they relate to each other, the research has a qualitative approach. In this regard, an instrumental case study is performed in an attempt to gain insight into the topics and generalize the findings so to be of use in different contexts (Stake, 2005).

The thesis is structured based on a deductive approach were relevant theory about the topics are combined into a coherent conceptual framework. The purpose of the framework is to analyse the case based on what is known about the topics to test the hypothesis (Bryman, 2012). In addition, the research has iterative connotation in relation to interactions. Since the main topic is the implementation of AM, interactions became a focus after some investigation on the subject, and was implemented into the research questions after discovering barriers to implementing AM.

3.2 Literature search

Finding relevant literature was done by searching with keywords in Oria and Google (both Google scholar and Google search engine). The main topic of this thesis, namely additive manufacturing was used as a search keyword in the early search process. In addition, this was combined with other key words such as “implementation” and “supply chain”. At first the search criteria were rather wide, in that if the paper heading contained additive manufacturing it was investigated. In addition to searching for additive manufacturing, other phrases in relation to the topic were used, such as rapid manufacturing and rapid prototyping. A list of the phrases that were used can be seen in Table 3.1. To complement the findings in the initial literature search, the reference list in articles that were interesting was examined, thus creating a snowball effect where more literature surfaced through reading. This is considered a crucial aspect of the research since this was part of expanding the knowledge about the topic, which was important for understanding AM and give more profound answers to the research questions.

The second topic of this thesis is the shared value creation framework, which is based largely on Porter and Kramer’s (2011) article. This topic was supplemented by literature on sustainability in relation to purchasing, logistics and supply chain management. The literature is collected by searching in Oria (university library), using the keywords "sustainable supply chain" and "sustainable logistics". In addition, different journals are leafed through, keeping an open mind looking for headlines and abstracts that could be of interest. The open search is meant to broaden the horizon of the thesis, and find other relevant keywords to search in Oria, such as "green".

Table 3.1 Key words used in literature search

Additive manufacturing	***Shared Value Creation***	***Interactions***
3D-printing	Green Logistics/SCM/Purchasing	
Rapid prototyping	Sustainable Logistics/SCM/Purchasing	
Rapid tooling		
Rapid manufacturing		

Interactions became a part of the thesis after researching literature on the other topics. Finding literature on interaction started with looking through previously read articles and books about supplier networks. Interactions was not particularly research by using keywords, but rather by reading articles and finding other publications of the authors, which expanded on Håkansson's (1987) model. This also lead to a snowball effect by finding supplementing literature in the reference list of such articles.

3.2.1 Grey literature

In addition to scientific journals, information was gathered through unconventional channels such as lectures available at various multimedia sources and news outlets. The reason for searching unpublished literature is due to the novelty of AM and the need to more profoundly understand its impact on industry and society. This includes public perception and how business relates to the technology. Especially organizations which have implemented or is trying to implement layered manufacturing technology in various degrees have been of interest. These sources of information have provided inspiration for the research questions, as well as shedding light on various practical applications. The unpublished sources of information have been regarded as secondary to published literature and are used to illuminate recent events in AM in line with Bryman's (2012) argument that academic texts take some time to be published, thus grey literature may be the only source of information.

3.3 Case

The case study started with an introductory meeting with the case company arranged through the SISVI project. The case company is one of the industry partners who participate in SISVI.

The first meeting consisted of a presentation of the tentative scope of the thesis and discussion about the topics of additive manufacturing and shared value creation. Initially, three specific projects at the case company were considered relevant to the thesis based on connections to SVC and technological development. The first project was a previously completed project aimed at improving tools using AM. The second project was an ongoing venture with customer, aimed at recycling plastic materials to create a closed loop in production, and lastly, a vision to enter the healthcare market, supplying products for elderly care. Considering the scope of the thesis, the first project was picked and thoroughly analysed. It may have been interesting to use the other project examples as well, but they were deemed too demanding to analyse in that they have little relation to AM and results would be speculations at best.

The chosen project and discussions with the case company guided the emergence of the conceptual framework in line with systematic combining (Dubois & Gadde, 2002). The nature of the project was such that in addition to the topics of AM and SVC, interactions in industrial networks needed to be considered. Thus, moving away from the aspect of AM's impact on SVC in different cases, towards an analysis of the intricate network of elements that made AM implementation possible and what impact it had on interconnected elements in the value chain. The framework was further developed throughout the research as interviews with key personnel added dimensions to, and altered initial preconceptions regarding AM. Especially regarding interactions, as perceptions from literature had to be altered to fit the research e.g. focusing on AM as a process as opposed to specific layered manufacturing technologies. This process of matching reality with the theory adds depth to the research in that the framework is renewed with new concepts that better fit reality (Dubois & Gadde, 2002).

3.3.1 Interview

Information about the case is based in two semi-structured interviews with key personnel in the case company. The interviews were completed based on an interview guide (A. Appendix) with specific questions, following Bryman (2012) guidelines for conducting a structured interview so that the context is the same for multiple interviewees (Bryman, 2012). However, given the nature of the research it was more beneficial to conduct semi-structured interviews as these gives the opportunity to ask follow-up questions and discuss unforeseen information that may come up. In addition, different interview subjects may have different views on the themes of this thesis, which take the conversation in a different direction, making structured interviews to rigid to be beneficial for this research. Thus, the interview guide was used to make sure each topic was covered.

Key personnel that were interviewed:

- CEO
- Development department, projects manager

3.4 Limitations

In systematic combining it would be beneficial to have more sources of data i.e. more interviewees that would result in redirection, and thus, keep evolving the framework (Dubois & Gadde, 2002). Additional sources of data to map the case company and the project were present through the project's website and newsletters with updates on project progress. In a systematic combining perspective, these sources of information result in redirection, but to fully utilize this aspect of a case study approach, more interviews should have been conducted with other actors who participated in the project. This could have expanded the understanding of how interactions in networks played a role in the implementation of AM, whereas now, the thesis focuses on interactions from the perspective of the case company.

3.5 Outline of the thesis

The following section presents an overview of how the thesis is structured.

- *Chapter 2* presents the context of the thesis and the overarching hypotheses that lays the foundation for the research questions
- *Chapter 3* describes the method of the research, including the approach to finding relevant literature for the different topics in the thesis.
- *Chapter 4* presents relevant theory for each of the topics. The topics are first presented in isolation, then combined into a conceptual framework in 4.4.
- *Chapter 5* presents the case company and a project the case company has undertaken, which will be analysed.
- *Chapter 6* present findings in the case based on the conceptual framework.
- *Chapter 7* discuss the findings in relation to the research questions.
- *Chapter 8* presents the conclusion based on the initial hypotheses.

4 Theoretical foundation

The following chapter presents the three main themes of the thesis.

- Additive manufacturing (AM)
- Technological development through interactions in networks
- Shared value creation (SVC)

The conceptual framework is based on the three topics of this thesis, namely additive manufacturing, interactions in industrial networks and shared value creation. This chapter present these topics separately and outline important aspects in each of them.

First, the topic of additive manufacturing is presented introducing how the concept is defined in this thesis. Following this, there is a section reviewing literature with the aim to illuminate what characteristics a product should hold to be viable for production with AM. In addition, the process of AM portrays a range of benefits, but also limitations, which are discussed in relation to the implications they may have in the value chain.

The concept of interactions is introduced, focusing on technological development in industrial networks. Interactions are derived from Håkansson's (1987) model for technological development, which presents a model for industrial networks and arguments that supports how interactions enable technological development in networks. Additionally, interactions are discussed in relation to literature on relationships, especially pertaining to buyer/supplier relationships in a development perspective. This includes the level of interaction that exist between buyer and supplier and how more or less control affects the outcome of relationships.

SVC is based on the framework from an article by Michael E Porter and Mark R. Kramer called Creating Shared Value (Porter & Kramer, 2011). SVC is also discussed in relation to literature on sustainable supply chains, sustainable logistics, and sustainable purchasing.

The topics are comprised into a conceptual framework at the end of this chapter, discussing how they may be regarded in connection to each other.

4.1 Additive Manufacturing

Additive manufacturing is a method of production and consists of many different technologies, among them are 3D-printing (Pham & Gault, 1998). This section gives a brief introduction to what additive manufacturing is and describes the process of AM. Additionally, distinctive characteristics of AM will be discussed in relation to what products are fit for AM. AM are being used in various contexts and some of these will be presented to provide the reader with real life examples of how the technology is currently being used. Lastly, AM is discussed in relation to implementation and the implications that this may have for an organization.

4.1.1 What is additive manufacturing?

Additive manufacturing is the process of applying material in layers to make a complete part. A model of the part is drawn in a 3D Computer Aided Design (3D-CAD) program, and the AM machine can create the part without planning the production process (Gibson, 2010). Technologies differ in how they apply layers, some merges the different layers together using heat to sinter whatever material is used. Some technologies use an adhesive to join granulates, and other technologies use UV light on light sensitive materials. Different technologies also present different material options, Stereolithography uses a bath of liquid polymer, and 3D-printing (3DP) uses granulated plastic. Laminated Object Manufacturing uses regular sheets of paper, and some technologies uses powerful lasers to melt metal wire or granulates to form the part (Pham & Gault, 1998).

“Additive manufacturing is a process of joining materials to make parts from 3D-model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing” (ISO/ASTM 52900:2015(E), 2015, p. 1).

The steps of the AM process is described here (Gibson, 2010) and illustrated in Figure 4.1

1. *Conceptualization and CAD.* The first step is to conceptualize the part you wish to create, and make a 3D-model in a 3D-CAD program. Not all parts are fit for AM, and before this step is undertaken the user should assess if the part qualify for AM. Parts made using AM must be specially designed for this production method, or designed for AM. One reason for this is because each layer has a finite thickness, making the finished part an approximation of the design (Gibson, 2010).

2. *Convert to STL format.* STL (derived from the word “Stereolithography”) has been the standard file format for layered manufacturing technologies (Gibson, 2010). However, this standard only defines surface mesh, and not colour, texture, material substructure, and other material properties. In collaboration with ISO, ASTM international has introduced a new standard file format called additive manufacturing file format (AMF) (ISO/ASTM 52900:2015(E), 2015). AMF is supposedly easy to use, technology independent, scalable and is backwards compatible with STL(Gibson et al., 2015). Additionally, AMF has all the benefits of STL, but with fewer limitations. The AMF

format also includes dimensions, colour, material. The STL file does not offer units of these values (Gibson et al., 2015).

3. *Transferring file to AM machine and manipulate STL/AMF file.* After drawing the 3D-model on a computer, the file containing the model is transferred to the AM machine. An operator may now manipulate the file by scaling it, and moving it around the construction substrate. This step makes it easier to make more than one part at the same time since you can stack them around the substrate.

4. *Machine setup.* Different machines and technologies have various levels of customization, but some of the regular ones are layer thickness, print speed and material choices. Those technologies that uses a printer head with liquid droplets will be able to choose the size of the droplets. The choices made by the technician at this point can have large consequences for the finished part's mechanical properties, as well as the time it takes to print. Thus, the operator must have knowledge about the end use of the part, since e.g. the machine can build a part twice as fast, but this will result in poorer resolution (Gibson, 2010).

5. *Building.* Step number 5 is reserved for the machine, which will build a real 3D-model of the part. Most machines run independently at this point, and human intervention is only necessary if the machine runs out of raw material or it malfunctions.

6. *Removal and cleaning.* Depending on the technology applied, different cleaning steps must be taken. Some technologies build support structures that requires removal, others use the excess material as support, which need to be cleaned of. Most technologies need attention at this stage, and if the work is done poorly it can result in damaging the part. For example, to remove the base plate of a metal part requires other machines.

7. *Post-processing.* When the part is finished, and taken out of the machine the part might require some post processing. Depending on the application of the part, this step can vary a lot in time consumption. Activities in this step are polishing, painting, heat treatment in cases of fragile components and machining due to accuracy discrepancies.

8. *Use.* The part is now finished and is ready for use.

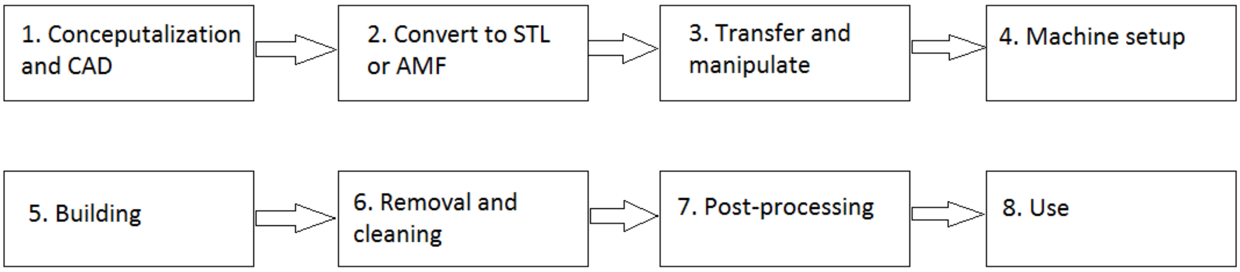

Figure 4.1 The process of AM from conceptualisation of idea to use of part

In this thesis AM refers to the complete set of process steps in Figure 4.1. 3D-printing and other layered manufacturing technologies are referred to as AM technologies. As is illustrated in Figure 4.1, AM refers to a set of processes, where AM technology is at the core. Only one step in the AM process is exempt human involvement, namely step 5, and even this step might require human intervention in cases of deviation. Evidently, AM requires skills and competencies beyond knowledge about AM technology.

4.1.2 Parts that are fit for AM?

As we shall see, AM is not beneficial for all types of product, and thus it is important to have some criteria to assess each part. This section provides some characteristics regarding what type of product is eligible for AM production, and at the same time gives an indication of the benefits of AM. A list of the characteristics that make a product fit for production with AM is provided in Table 4.1

Low volume production and parts that require multiple moulds are identified as a situation where AM can be used (Achillas, Aidonis, Iakovou, Thymianidis, & Tzetzis, 2015). Low volume parts are desirable because the investment in production equipment for a low volume part might be unjustifiable, especially if the equipment is asset specific. Another aspect is the cost of inventory, which can be avoided by using AM in the case of low volume parts, as it can be produced on demand. Low volume products can also apply to moulds where one uses AM for rapid tooling (RT) by producing moulds with AM technology (Conner et al., 2014). Thus, the “low volume criteria” can be circumvented by producing moulds to manufacture high volume end-products. In situations that require multiple moulds, AM can reduce lead time by producing the entire part or components of the part, thus eliminating or reducing changeover time.

Other authors have found that potential applications for AM are characterized by small production output, high product complexity, high demand for customized products and spatially remote demand for products (Weller, Kleer, & Piller, 2015). High product complexity refers to the ability of AM to produce complex parts without raising cost in manufacturing. Examples of this are internal structures in a part, that is made possible because AM builds the part from the inside out, contrary to subtractive manufacturing. AM is also a favourable means of production if there is a demand for customization or variation. AM offers the freedom to rapidly change the design of a component without the need for changes to the production equipment, which is illustrated in step 1 and 2 of the AM process in Figure 4.1. Furthermore, this also relates to variation, where AM offers flexibility in variety with reduced changeover time because the variation of a design can be done in step 1 or 2 while other parts are being built.

The characteristics made by Weller et al. (2015) are typical in literature, but spatially remote demand has been challenged on the basis that this would lead to excessive cost connected to the cost of AM machines, the machine operators, raw material and material inventories. The distributed deployment of AM capacity must be driven by a need for fast response and flexibility and is a viable option for distributed production if the value of keeping asset specific production equipment operational is high (Jan Holmström, Jouni Partanen, Jukka Tuomi, & Manfred Walter, 2010).

Table 4.1 Characteristics of products that are fit for AM

Product characteristic	***Literature***
Low production volume Innovative products	(Achillas et al., 2015)
High complexity Customized products Cost of obsolescence is high	(Weller et al., 2015)
Geographically Dispersed demand	(Weller et al., 2015) (Jan Holmström et al., 2010)
Tools (rapid tooling)	(Conner et al., 2014)

The characteristics in Table 4.1 are associated with AM's capability to reduce setup time and produce on-demand. However, the process of AM in Figure 4.1 indicates that one should approach this notion with caution because there are multiple operations to consider beside part manufacturing. The characteristics gives a good indication of what types of products are fit for AM, but lead time reduction and cost savings must be assessed compared to conventional methods for AM to viable (Conner et al., 2014).

A final observation is that AM supports reduced lead time in design changes and production. Consequentially, this can reduce the time to market for new products, thus supporting innovative products (Achillas et al., 2015).

4.1.3 Implications of additive manufacturing

When considering AM as a production method, there are some aspects that need to be assessed to find the right use for the technology. With respect to the process map, the first aspect to consider is if the product has the characteristics of an AM part. Second, the AM process indicates that there are aspects relating to the organization because of the need for diverse activities and resources in each process step.

4.1.3.1 *Cost.*

Additive manufacturing technology requires financial investment, which is a limiting factor to expand AM capacity (Mellor, Hao, & Zhang, 2014). Additionally, AM requires qualified personnel to operate the machines, which also adds cost (Jan Holmström et al., 2010). The cost of personnel and machines will increase if AM is to be used at more than one location (dispersed capacity) because of the need to linearly purchase more machines and employ more personnel as the number of locations increase. The process steps indicate that the need for human intervention on AM machinery is quite small, thus, if all AM machines are located in the same place (centralized capacity), the need for personnel will decrease, and might even be as small as one. Consolidation of AM capacity defeats the purpose of the movable production facility to some extent, but is an opportunity for consolidation of knowledge and resource coordination. If used as a logistics hub it can be a positive way to consolidate demand at one place (Jan Holmström & Jouni Partanen, 2014).

Another aspect of cost that should be considered is cost connected to the environment. In metal printing, leftover particulates must be removed from the work area, which is usually done with a liquid separator vacuum. The waste water from the process contains metal particulates, which characterises it as hazardous material. Consequently, this adds costs due to high charges for disposing the water and the lost metal powder that could be used in production. Therefore, an additional environmental cost is present because of the sizable water-use in the cleaning process, as well as the waste waters' own impact on the environment, especially if it is not handled correctly (Fuges, 2016). As a result, there are some environmental issues connected to AM, which should be explored. Additive manufacturing is also energy intensive, which incur energy cost, but also a cost to the environment (Weller et al., 2015).

Due to slow build speed, the process cost of AM is high. However, this will likely change when the technology matures (Gibson, 2010; Mellor et al., 2014)

4.1.3.2 *Materials.*

Raw materials for additive manufacturing carry different challenges to potential AM users. First, the cost of the material, specifically for metal printing is a major cost driver and can be as much as ten times the cost of materials for traditional manufacturing (Douglas S & Stanley W, 2014). Second, materials are often delivered by the same supplier who delivers the machine. This poses a supply risk, as the supplier is left with all the power in the relationship. Consequently, this can have a negative impact on the purchasing price and pose a supply risk to the buyer.

4.1.3.3 *Quality.*

Another barrier to AM is the quality of finished parts, which is a problem due to lack of standards in the AM industry. Especially the aerospace industry which requires strict certifications can be affected by this. Parts made with AM technology may have varying accuracy depending on technology (Gibson et al., 2015). Therefore, one technology may not be sufficient, depending on the range of products to be manufactured. Quality implications may also incur cost and complexity in design and post-processing due to varying accuracy.

4.1.3.4 *Organization.*

A company who wish to implement additive manufacturing must consider organizational factors. First, it is important to recognize what resources are present in organization. Not all firms possess the required skills and capabilities to use additive manufacturing technology effectively. For example, step 7, Post-processing, require some form of machining skills, especially if the products are to be sold to customer with high quality demands (Mellor et al., 2014). On the other hand, Mellor et al. (2014) express that this is a trade-off, and that an organization could put more effort in the design phase, focusing on design for quality. As a result, the organization could perhaps evade or reduce the resources put into the post-processing step. However, this requires more processing upstream, in addition to a design/product development capability.

4.1.3.5 *Logistics and supply chain.*

An argument about the positive aspect of AM is the potential to quickly ramp up manufacturing capability close to customers (Huang et al., 2012; Jan Holmström & Jouni Partanen, 2014), which would reduce the lead time experienced by customer. However, the transportation cost of raw materials will rise as a result of this and it will result in more inventory of raw materials (Daniel R Eyers & Andrew T Potter, 2015). This trade-off must be weighed based on what type of raw material that's in use. If there are many types of raw materials it can result in a complex inventory, where obsolescence may become an issue. Furthermore, this can be extra difficult, due to the high cost of materials (Douglas S & Stanley W, 2014). To address the issue of cost, it is possible to look to logistics service providers. The cost of AM machines are quite high, and will have a big impact on smaller companies Consolidation of the demand could enable a logistic service providers to invest in the technology and service a range of companies by using AM at strategic locations (Jan Holmström & Jouni Partanen, 2014).

4.1.3.6 *Communication*

Eyers & Potter (2015) found that AM through E-commerce channels for Additive Manufacturing (eCAM) would facilitate more communication with customers, resulting in a better understanding of customers' needs, and better position to deliver customized products. However, customers would be required to know what is practically feasible by AM and the lack of this knowledge could present a challenge. The supply chain would either way be affected by communicating with customers, and would result in better visibility, leading to an optimized production plan (Daniel R Eyers & Andrew T Potter, 2015).

4.1.4 Uses of additive manufacturing

AM has become more mainstream with the years, and this section present some companies and industries where AM is being utilized.

4.1.4.1 *Rapid prototyping*

Additive manufacturing has been used for rapid prototyping (RP) for some time. RP is a concept in which a manufacturer makes a design of a part and uses additive manufacturing technology to rapidly make a prototype of the part (Jan Holmström et al., 2010). However, this is only the beginning of the possibilities of the additive manufacturing technology because it has evolved through the last thirty years (Huang et al., 2012). As it becomes more sophisticated, the technology can produce more high-quality parts in different materials, which broadens the scope of usage. There is an ongoing transition where some companies are trying to make the move from rapid prototyping to rapid manufacturing (Mellor et al., 2014). This focus seems to be about exploring the applications for metal AM.

4.1.4.2 *Aerospace parts manufacturing*

Norsk Titanium AS are set to produce parts for use in the Airbus A350 XWB ("Norsk titanium skal lage titandeler for Boeing," 2016). The potential to create lighter parts due to the ability to create internal structures makes AM attractive to the aerospace industry. Lighter parts may be one of the key features to transfer to other industries. Especially from a sustainability perspective, because lighter parts in vehicles will reduce their fuel consumption (Gebler, Schoot Uiterkamp, & Visser, 2014). Consequentially, this is beneficial for the environment, and from a cost perspective. Weight reduction is calculated to reduce fuel consumption by 9-33% (Gebler et al., 2014).

4.1.4.3 *Siemens*

Siemens are producing gas turbines with the use of layered manufacturing technology. The turbines were previously produced by combining two parts by welding them together. AM makes this step obsolete by printing the two parts together in one process step. In addition, cooling ducts are printed into the turbine blades, which earlier was done by drilling, making them more effective. Siemens believes that by using AM, the time to repair certain models can be reduced by as much as 90 % ("BRANDSTORY," 2015). However, it is important to consider that AM machines are not necessarily fast and that the print speed could offset this number. Also, the printed turbine blades might not have the strength required, considering the blades move faster than bullets at the tip, thus invoking a lot of G-force.

4.1.4.4 *Bio printing*

As previously mentioned, AM can make tiny complex structures inside the object it's creating. This is an exciting feature for the medical industry as Bio printing could be able to produce biocompatible scaffolds embedded with growth factors. These could in turn be seeded with stem cells to grow organs (Michalski MH & Ross JS, 2014). However, it is difficult to make the microstructures at this small level, and at the required strength. 3D-printing (3DP) and Selective Laser Sintering (SLS) could make its bindings strong enough, but the extra use of laser or binder would bind more particles, and increase the dimensions (Chia & Wu, 2015).

4.1.4.5 *Healthcare*

Dentistry has used AM technology for a decade making moulds for many common dental implants (Huang et al., 2012). Blueprints of for example prosthetics can be shared and manufactured by a personal 3D printer. In this way a person will be able to produce his or her own prosthetics as the body grows with a few adjustments to the 3D model (Berman, 2013).

Additive manufacturing is used in healthcare, for example by producing customized artificial limbs and prostheses in addition to be used to make dental products like bridges and crowns (Huang et al., 2012).

4.1.5 AM and SVC, results from literature review

The following section presents the findings in the literary review about AM and its potential to create shared value (Sletfjerding, 2016).

4.1.5.1 *Operations*

Additive manufacturing can result in increased efficiency in manufacturing certain products and safer work environments for employees. This is illustrated in Siemens effort to produce burning tips for gas turbines using AM. First, they shortened production time for the product. Particularly because Siemens' earlier had to create two separate parts and weld them together, where AM technology could make the whole part in one cycle. Second, by excluding the welding step of the process, the production has become safer, as the dangers with welding was eliminated.

4.1.5.2 *Sales and marketing*

AM enables the user to customize products to customer's specification. In a shared value perspective, this is especially interesting for health applications. Since there is no extra cost for customization, products in need of customization is cheaper, and thus become available to more customers. Also, products like hearing aids and artificial limbs, which needs to be adjusted to a growing body can be produced cheaper.

4.1.5.3 *Inventory*

Additive manufacturing provides the opportunity to reduce finished goods inventory, as well as spare parts inventory. The latter is especially interesting because the possibility to produce spare parts for a product that is out of production will enable it to stay operational. Keeping machines operational for longer can create shared value if the price of service is lower than buying a new machine, and that the overall energy use of service is lower than producing a new machine.

4.1.5.4 *Logistics*

Siemens explore the possibility to set up AM capacity in different locations to reduce lead time for spare part delivery. Resulting in the possibility for shorter transportation distance, thus reducing CO_2 emissions. However, it's important to clarify that the total transportation will be the same, because raw materials for machines must be transported to the locations. If this were to become reality it is important to assess the centre of gravity (Christopher, 2011) and use the mobility of AM technology to find the most cost effective, and environmentally friendly point of deployment. These “mini-factories” will open for value creation and more environmentally friendly transportation methods, because the shorter lead time allows re-stocking in smaller batches. However, decentralising AM capacity will require more manpower, thus raising cost, which can devalue this aspect.

4.1.5.5 *After sale*

Some AM technologies have the possibility of adding material to an existing part. This ability opens for repairing products and parts on location in situations where one would usually need to order new parts. The aerospace industry has shown potential in using AM to achieve an extended life cycle through servitization (Jan Holmström & Jouni Partanen, 2014). However, this would demand skilled personnel on location, which would add cost in addition to the cost of machines and raw materials inventory.

4.1.6 Aspects of implementation

The literature has highlighted that additive manufacturing may be beneficial in several cases, but that it should be approached with caution due to its limitations such as cost. Benefits and limitations are summarized in Table 4.2. Consequentially, an organization which wish to implement AM needs to assess their product, process and organization. First, it’s important to assess the strategy of an organization, and analyse if AM can benefit its competitive position. AM contain several benefits, and the purpose of AM in the organization must be clear, and in line with these benefits. It is paramount that the products the firm delivers are reliant on some of the characteristics of AM because the cost will quickly offset the benefits if not.

Table 4.2 The benefits and limitations as identified in the literature review

Limitations	***Benefits***
Cost Energy use Raw material cost High experienced workers Machine cost Range of materials Quality/consistency Size of build Skills and competencies in both AM and other complimentary activities	Design freedom, changes in product design Complexity, integrated geometry Less materials required/less scrap Manufacturing flexibility/variety Customization Fast product innovation No finished goods inventory (MTO) One-step-production

The research questions emphasise implementing AM to create shared value. The following paragraphs presents an overview of the important implications of implementation, derived from Mellor's et al. (2014) framework for implementing AM in a firm who previously used AM technology for rapid prototyping.

1. *Competitive positioning*

AM include benefits connected to competing on customization. A company with the intention to implement AM should have a focus on utilizing the aspects of AM that can bring benefits. An organization may refer to Table 4.2 in order to evaluate if their competitive positioning is in line with the benefits AM provides. For example, AM are more fit for customization and make-to-order (MTO) than economies of scale, and if an organization is focused on cost leadership, AM technology might not be a strategic fit.

2. *Purpose of AM*

Implementing AM should have a purpose, such as improving a product or process. Since the cost of AM is high there needs to be a specific plan on how it can benefit customers and the organization. Here it is possible to look at aspects of a product and compare with the list of parts that are fit for AM in Table 4.1. However, the specific uses of AM are illusive and the purpose of AM should be approach with an innovate capability.

3. *Effects on organization*

An organization who implements AM must assess what this means in terms of how they are organized. Depending on the organization it might require developing new skills and competencies in design, AM technology, material knowledge etc. The implementation might also make some positions obsolete while creating new positions elsewhere, thus requiring a shuffling of positions within the organization, which points to a need for dynamic capabilities (Teece et al., 1997).

4. *Effects on value chain*

There are bound to be effects on the value chain when implementing AM, on both primary and supporting activities. Technological development will gain a new resource and need new activities in relation to product design and process design. The purchasing function will experience different challenges due to new suppliers becoming relevant. The logistics function may be revised in relation to inventory, both raw material, which might be more complex, and finished goods inventory, which might be less complex. AM of finished products, or by using it as RP will alter how the sales function communicates with customers by being able to convey ideas and make changes to design on customers' requests. As discussed, the after-sale and service function may experience new possibilities related to an extended lifecycle for products through servitization.

4.2 Interactions

The following section presents the concept of interactions, and a model describing technological development in networks. The model is based on various sources, including resource interfaces (Araujo, Dubois, & Gadde, 1999), The creation and operation of a supply network (Harland, Zheng, Johnsen, & Lamming, 2004), Industrial technological development: a network approach (Håkansson, 1987), Strategizing in industrial networks (Gadde, Huemer, & Håkansson, 2003) and Strategic networks (Gulati, Nohria, & Zaheer, 2000).

The main argument of this section is that to transform an invention into an innovation, different activities and resources needs to be combined into novel resources and activities. The chapter is outlined as follows, first, the concept of interactions is introduced. Second, a model that illuminate industrial networks and its elements, presenting Håkansson's (1987) network model. Third, based on the model, Håkansson's (1987) three arguments for why technological development appears through interactions in networks are introduced. The arguments are knowledge creation, resource mobilization and resource coordination.

The focus on interactions in this thesis is based on the assumption that collaboration with suppliers is beneficial for development projects. The rationale for collaboration in relation to new product development are discussed by various authors (P. Cousins, Lamming, Lawson, & Squire, 2008; R. B. Handfield, Ragatz, Petersen, & Monczka, 1999), and the network approach is argued to be a favourable tactic to organize the implementation of new manufacturing technology as these consists of close relationships that provide resource efficiency (Bessant, 1994). On the other hand, networks also provide an agile aspect since participating organizations may have independent decision making processes, thus making them more responsive in relation to their resource configuration (Choi, Dooley, & Rungtusanatham, 2001)

4.2.1 Interactions – a process

The definition of interactions in the thesis is derived from a description of relationships, arguing that they are best illustrated as a continuous process with inputs and outputs (P. Cousins, Lamming, Lawson, & Squire, 2007). Inputs to the process are the actors and resources the actors bring with them. Through the process, resources are transformed into products or services and constitutes the output of the relationship. Interaction is the intersection between actors where they perform activities that combines each other's resources as depicted in Figure 4.2. A relationship is regarded as a resource and can be an input or an output to the process.

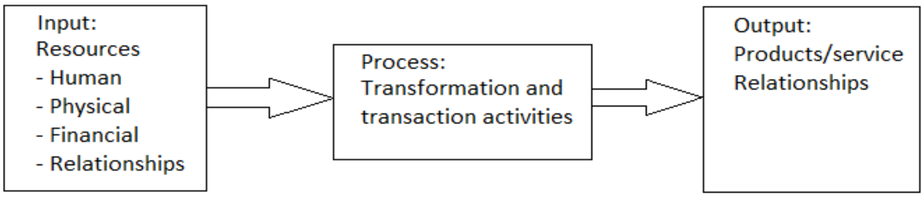

Figure 4.2 Relationship as a continuous process, derived from Cousins et al., (2007)

The definition by Cousins et al (2007) requires two entities, but this thesis will consider the perspective of polygamous relationships in networks. Due to the assumed barriers of implementing AM, it's reasonable to believe that the skills and capabilities needed are found with a variety of actors, thus several partners will affect the implementation process. Polygamous relationships encompass, apart from the activities between two actors, also the effects such a relationship may have on other actor relations.

4.2.2 Interfaces

Interactions can have various levels of intensity. To illustrate this, the concept of resource interface is introduced. An interface is the intersection where resources from a buyer and a supplier are confronted with each other (Araujo et al., 1999). The interfaces have consequences, including benefits to innovativity, productivity, and cost related to the intensity levels of the interaction. The following section briefly describes the interfaces, which describe relationships ranging from arm's length relationships to close collaborating relationships (Luis Araujo, Lars-Erik Gadde, & Anna Dubois, 2016). The main characteristics of each interface is presented in Table 4.3.

1. *Standardized interface*

Standardized interface requires minimal interaction and is characterized by the transfer of standardized products. The supplier can take advantage of learning curve effects and economies of scale, which in turn trickles down as a benefit for the customer. The cost associated with this interface is mostly the purchasing of the product, but might also be found in indirect costs elsewhere. There is no innovativity to gain for the customer.

2. *Specified interfaces*

Customers provide specific directions on product, such as how it's made. There is a possibility for the supplier to gain economies of scale by pooling similar orders. The cost associated with productivity is that suppliers lock-in their resource base and have little possibilities to influence specifications. There is little innovativity gains in this interface, and because of the lock-in, development of the supplier's resources may suffer.

3. *Translation interfaces*

The buyer specifies the user context and functionality that is required, but gives the supplier freedom to propose innovative solutions. This can result in more efficient solutions that provide better productivity. However, the supplier may not share all benefits with the buyer, thus creating cost for buyer. Even though the supplier has freedom to innovate, they might not have enough knowledge about application context of the product to innovate sufficiently.

4. *Interactive interfaces*

Interactive interface is based on joint development and combines the knowledge of the supplier and the buyer. There is cost related to both productivity and innovation because the interface demands investment in the relationship as well as learning activities and knowledge development. Provided enough investments are made, interactive interface yield productivity returns in the form of shared cost consideration, and innovation returns due to suppliers having increased information about buyer context.

Table 4.3 The four interfaces showing the prospect for innovation rising as the interface becomes more intense as the actors have more knowledge of each other's resources (Araujo et al., 1999).

Interface	***Characteristics***	***Productivity***	***Innovativity***
Standardized	Minimal interaction Sourcing standardised goods	Supplier's learning curve	None
Specified	Supplier given blueprint of product Outsourcing	Supplier can pool orders gaining economy of scale	Little to none due to low supplier autonomy
Translation	Context and functionality of product	Supplier may have productivity enhancing solutions	Supplier can make innovative suggestions
Interactive	Joint development	Shared cost	High possibility for innovation

4.2.2.1 *Strong and weak ties*

Håkansson (1987) stresses the importance of strong and weak ties. Strong ties are defined as close relationships where internal resources are combined with external resources (Håkansson, 1987). They can be compared to the interactive interface due to the close contact between the organizations. Conversely, weak ties are not relationships, but spring out from interaction with actors without having a relationship. This interaction is mostly on an individual level and informal (Granovetter, 1973 in Harland et al., 2004). Communication channels which can enable information transfer in the network is considered to be the defining behaviour of weak ties (Håkansson, 1987).

4.2.3 Network model (Håkansson, 1987).

The actor, resource and activity model in Figure 4.3 provides a description of what a network is and how it functions. The following section presents the elements of Håkansson's (1987) model and how they are connected.

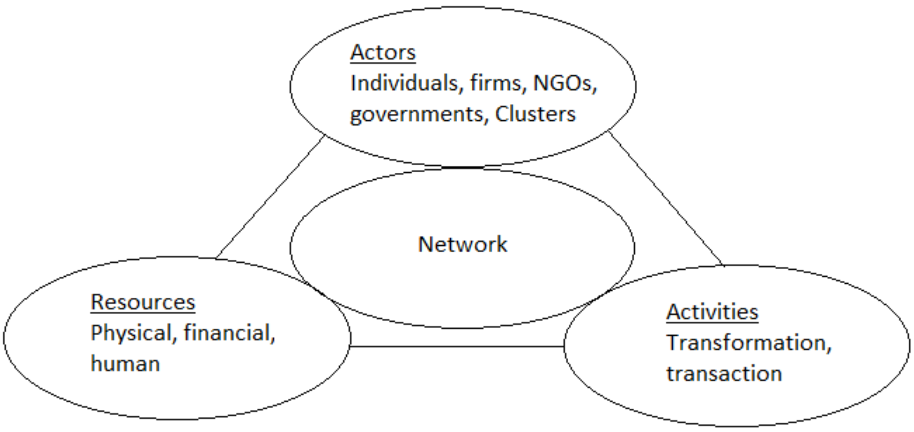

Figure 4.3 Håkansson's (1987) network model derived from Industrial technological development: A network approach (p. 17)

4.2.3.1 *Actors.*

Actors are defined as individuals, organizations or a group of organizations that perform activities and/or control resources. Actors are described based on activities the actor performs, the resources the actor controls and knowledge the actor has about resources, activities and other actors in the network.

Actors are the structure of the network, and by influencing each other through different activities the network evolves (Choi et al., 2001). Furthermore, actors can influence the network by taking various positions on collaboration. Through aligning positions actors may gain leverage over suppliers, change or set industry standards or engage in technological development (Meyer & Wit, 2014). There are potentially many different actors that can be involved in a network. Actors are not necessarily firms, but includes, governing bodies, NGOs or research clusters etc., which must be considered due to their power to influence in different ways for example by creating policies or introducing research that could affect other actors in the network (Meyer & Wit, 2014).

4.2.3.2 *Activities.*

Activities are performed to transform resources. There are two main categories of activities, namely transformation and transaction activities. Transformation activities are characterized by one resource being modified by combining it with other resources. Transaction activities supports transformation activities by transferring resources between actors (Håkansson, 1987). The network perspective focuses on coordinating activities with other actors to enhance productivity (Gadde et al., 2003). De Wit and Meyer (2014) provides an example in lumping relationships, where similar activities like logistics systems are synchronised to improve visibility and just-in-time deliveries. However, due to the demand to invest in similar technology in this scenario, dependencies arise, which needs to be systematically managed, because interdependencies are important to gain full advantage of the relationship (Gadde et al., 2003).

4.2.3.3 *Resources.*

Resources are physical assets (machines, material), financial assets and human assets (knowledge relationships). Relationships are resources in themselves, for example the relationship with customers is a resource because it provides income for the focal firm. The relationship also provides a link to other companies' resources, opening for combining and recombining them with the firm's internal resources. Furthermore, customers have knowledge about application of the product they're buying, which is useful to the supplier's technological development (interactive interface). Consequently, the value of the supplier's resource can be altered through the relationship by combining it with the application knowledge of the buyer (Gadde et al., 2003). Relationships are important resources because they connect a firm to the network, and through this makes more resources available (Håkansson, 1987).

4.2.4 Interconnectivity of the elements

Interactions in a network contain the three elements, actors, activities and resources. These elements are interconnected and must be considered in conjunction (Gadde et al., 2003). The resources an actor possess guides the activities an actor can and should perform. This statement will be discussed in relation to Strategic alignment and Interdependencies by considering the input/output relationship model of Cousins (2007).

4.2.4.1 *Strategic alignment. Expectations and result.*

1. *Consider output*

Considering the output first, strategic alignment can be defined as performing activities and allocating resources according to higher lever strategy (P. Cousins et al., 2008). This entails measuring activities performed by individuals or the organization by assessing the resources that constitutes the output (P. D. Cousins & Spekman, 2003). The output is, as mentioned earlier, goods or services from transformed resources. In this thesis, output is focused on technological development through interactions. The desired output must be communicated in the organization, be it cost, quality or innovation so everyone involved understands what are expected from the interaction. In essence, actors must consider what should be the outcome of the project based on the strategic focus of the organization The importance of considering the outcome is evident because relationships, and especially close collaborating relationships are resource intensive (Araujo et al., 1999; P. Cousins et al., 2007)

2. *Match with input*

To achieve the desired output of interactions, actors must invest resources in the project. Actors must consider internal resources that are available, and allocate the correct resources as a function of the envisaged outcome. In addition, external actors' resources must be assessed because these are an important input for the interaction (R. B. Handfield et al., 1999). With a clearly desired outcome of the interaction the actor must also examine the available resources in the network and articulate what is needed to the respective counterpart. Choosing the right actor and connecting to their resources is done through various transaction activities. Dependent on what the outcome of the interaction is, these activities differ in how resource demanding they are (see interfaces).

3. *Measure*

Lastly, it is important to assess the project, which is done through measuring the output of the project. Referring to the strategic goal, Cousins (2007) presents criteria for measuring the success of a project as SMART (Specific, measurable, achievable, relevant and time bound). Measuring are important, especially in polygamous relationships due to there being multiple actors seeking to gain something from the interaction. Thorough measuring of the output contribute to participating actors having a better understanding of how their contribution achieves benefit for themselves and the cooperation (Monczka, Petersen, Handfield, & Ragatz, 1998).

Strategic alignment shows how interactions connect actors through continuous processes and how interactions alters actor dimension. The activities an actor performs before, during and after interactions should be assessed regularly. Especially since the output of the interaction can alter the available resources, thus providing new opportunities for inputs. This in turn alters the position of the actors and the activities they must undertake.

4.2.4.2 *Interdependencies.*

Interfaces have different demands for resources and the intensity of activities the actors perform. The different interfaces poses different levels of dependencies between the actors, where standardized interfaces have low or no dependence and become more intense moving towards interactive interfaces (Araujo et al., 1999).

In business relationships, various degrees of dependencies arise within different contexts. These contexts can be technological, knowledge, social relations, administrative routines and systems and legal ties (Håkansson & Snehota, 1995). Organizations are connected through such dependencies by using the same information systems or having specialized technology fit for each other's operations. The context of technology and knowledge are resource based contexts. Transaction activities that are performed by actors in a relationship will affect the level of interdependency in relation to the resources involved in activities. Furthermore, these interdependencies have implications for the surrounding network actors through the concept of connectedness, which describes the network environment as relationships that are connected. For example, the relationship of a buyer and supplier is affected by the relationship between the supplier and its supplier (Blankenburg & Johanson, 1992). This explains the interconnectedness of the element of a network, because when actors interface with other actors, they transfer and alter resources, which alters what resources a company has access to. Consequentially, interdependencies dictates to some degree what activities can be performed due to the change in resource configuration. Interfaces poses different levels of interdependencies and have impacts on other relationships the actors are engaged in (Araujo et al., 1999).

Initially in this section we introduced the actor dimensions and the discussion of interdependencies and connectedness shows the importance of the knowledge actors have about the network. In addition, one can try to control these connection, which makes sense if the connection has strong impact on the relationship (Blankenburg & Johanson, 1992). However, engaging connected actors imposes cost, and controlling these should be approached with caution.

Interdependence and connectedness explains how the elements are variables in the network. As actors are interacting in combining resources or by transferring the control of a resource to another actor the network is evolving because of the cascading effect this has on other relationships. It is important to be aware of these changes because the resources that are available to an actor dictates what activities it can perform. We have also seen the importance of strategic aligning resources and activities in relation to the outcome of interactions. Being aware of the impact interactions have is important in an everchanging network and should be managed and monitored to gain access to important resources (Andersen, Cook, & Marceau, 2004).

4.2.5 Technological development - Processes in the model.

Technological development is a process of innovation where new solutions are invented to improve an aspect of a business. This can be improved raw materials for a certain product, processes that makes production more efficient or improved functionality of an existing product etc. Essentially, it is supposed to add value to the product or service offered by a business (Håkansson, 1987). Håkansson (1987) argues that technological development and innovation happens in interactions between actors and bases this on three arguments; knowledge development, resource mobilization and resource coordination.

4.2.5.1 *Knowledge development*

Innovation emerges at the interface of different knowledge (Håkansson, 1987). Knowledge can be new products or processes, application knowledge about certain technology, manufacturing capability etc. For example, in a supplier/buyer relationship the knowledge of the supplier interfaces with the knowledge of the buyer, which the buyer in turn transforms into a product, or use in a process. Thus, the knowledge of the buyer is combined with the knowledge of the supplier. Transaction activities supports knowledge development by transferring resources between actors. Essentially, novel solutions are a product of the combination and recombination of different resources and knowledge (Håkansson, 1987).

The type of knowledge that are exchanged differs, based on the characteristics of the interface. Resources can interface at various levels, which provide different levels of learning and innovativity, of which an interactive interface provide the highest level of innovation (Araujo et al., 1999). Interactive interfaces are however more resource intensive than other interfaces, for example Standardized interfaces which has low switching cost and does not require investment in the relationship. However, standardized interface does not offer innovativity, but it still provides some form of "new" knowledge relative to the knowledge put into the process. The interfaces show how different knowledge is transferred between actors in the network. For example an interactive interface can yield tacit knowledge transfers because trust between actors eases the flow of tacit knowledge (Dyer & Nobeoka, 2000), while standardized interfaces yield explicit knowledge.

Regarding a network, it is not only the immediate relationships that needs to be considered, but also that actors further away in the network has resources that could help renew the innovation process. The difference between strong and weak ties illustrate this point. Håkansson (1987) stresses the importance of weak ties because these are much less resource demanding than strong ties (close relationships) and can be a source of new information, thus enabling knowledge development. Admittedly, the best basis for innovativity is the interactive interface, but is supported by information channels through weak ties (Harland et al., 2004).

4.2.5.2 *Resource coordination*

The resources an actor control is limited and if an actor lacks certain resources for a development project, these might be accessed through other actors in the network. Involving suppliers early in the product development process can have positive effects on cost and quality (R. B. Handfield et al., 1999). This leads to the next argument of technical development, which is resources coordination. New knowledge arises at the intersection of closer relationships when the resources are interfaced interactively (Araujo et al., 1999; Håkansson, 1987). Resource coordination is a process that deals with the fact that other actors are better at certain things, and coordinating internal resources with these actors could prove beneficial as demonstrated in literature that has found that integrated production networks outperform non-integrated ones (Dyer, 1996; Dyer & Nobeoka, 2000).

From a network perspective, this does not necessarily happen in a dyad, but with many different actors who possess resources relevant to a certain development project. Considering a purchasing perspective, coordination between buyer and supplier can lead to a more efficient execution of supply. This is illustrated by the transaction activity of information processing (Harland et al., 2004), where creating more visibility through information sharing technologies, can reduce demand distortions. Harland (2004) also exemplify resource coordination through the activity of resource integration where actors are sharing both human resources (knowledge of product or process) and physical resources (manufacturing equipment). The activities are connected to the interactive interface, and are thus resource demanding and should be managed by executing other transaction activities in parallel to raise certainty. Likewise, this also addresses the importance of actors to be aware of what resources and skills are present in the network. As knowledge about supplier capabilities is critical for success in product development (R. B. Handfield et al., 1999), it's important to recognize other actors in the network when coordinating resources. Hence, the importance of both strong and weak ties, as the weak ties can yield the needed information about other actors.

Resource coordination comprises a variety of actors, but the common denominator is that they are connected to a close relationship. However, actors benefit from performing other activities connected to weaker ties to collect information that can be valuable in assessing the network. The main goal of resources coordination is to interface various resources and knowledge to achieve knowledge development. Next, the concept of resource mobilization will be presented, which is the process of receiving the new knowledge into the organization.

4.2.5.3 *Resource mobilization*

When an invention or knowledge is presented into a firm, it will become dependent on other processes, products or services (Håkansson, 1987). The new knowledge is of no value if the actor cannot apply it in their operations, which means it's essential that the organization perform activities that support learning processes connected to adaptation of the new knowledge. Resource mobilization is defined as assigning resources to new knowledge and perform transformation activities on that knowledge (Håkansson, 1987). An actor needs to mobilize resources to make the invention useful for the situation, thus make it an innovation. Håkansson (1987) argues that the innovation process can be compared to mobilizing resources because innovation activities are essentially assigning resources to new knowledge. It is important however, to recognize that the resources that needs to be mobilized are at contest from other activities in a firm (Gadde & Snehota, 2000), which shows the importance of mindful prioritizing in resource mobilization. If knowledge that is presented to the company doesn't get enough resources, such as human resources, opportunities will be wasted. Mindful resource mobilization is especially important if the resources in question are scarce, or the activities are resource intensive. Another question is what resources to mobilize, which is dependent on the knowledge the firm has acquired, or wants to acquire. If it's a new technical solution it is likely that the firm will mobilize R&D resources to be able to adapt the new solution to the firms' processes, thus making it an innovation. In some cases, mobilizing resources is not about innovation, but about implementing new knowledge, leading to mobilizing human resources and perform learning activities.

Knowledge development, Resource coordination and Resource mobilization must, like the elements of the network, be seen in connection to each other. Knowledge development is driven by coordinating resources with other actors. Resource coordination demands resources to be mobilized, and the knowledge gained from this interaction, for example a new process, must be adapted to the actors existing processes through resource mobilization. The proposed interconnectedness is illustrated in Figure 4.4. The degree of interface between two actors lay the foundation for which knowledge is developed. When coordinating resources, actors decide the degree of interface, and mobilize resources based on this decision.

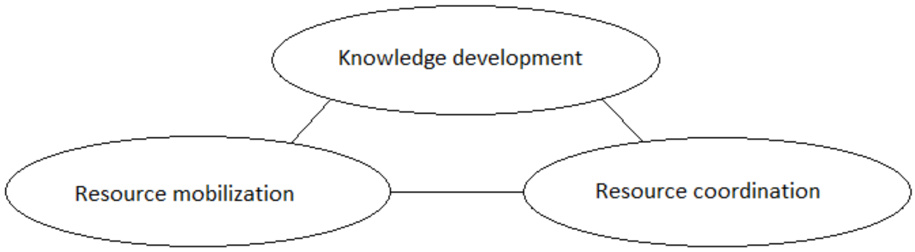

Figure 4.4 The interconnectedness of Knowledge development, Resource coordination and Resource mobilization

4.2.6 Interactions framework

The following section presents the arguments of technological development as it is thought to be applied in the conceptual framework. Based on these arguments, the interactions in the case will be analysed. The framework is based on the arguments for technological development in networks by Håkansson (1987) and activities described by Harland (2004) for operation in supply networks.

4.2.6.1 *Knowledge*

The starting point would be to evaluate what knowledge is required for the technological development. This is important because in interactions both intended knowledge and unintended knowledge might appear. By having a planned outcome for a relationship, the relevant knowledge can be sorted out, and as has been demonstrated in resource mobilization this is imperative due to limited resources for learning activities and transformation activities of the knowledge in question. To best utilize the network, it is crucial to have strong and weak ties because new knowledge can be picked up through the weak ties, which is decisive for bringing novel ideas to the table. At the same time, the strong ties of the actor must be considered because there is already invested a lot in them and these are the main sources of knowledge development.

To support knowledge development an actor should engage in Knowledge capture and Social coordination (Harland et al., 2004). Knowledge comes in the forms of tacit and explicit knowledge, which are transferred differently (Dicken, 2011). Explicit knowledge requires the actor to be aware of what knowledge is out there and what knowledge it seeks. Explicit knowledge is transferred with relative ease as it can be written down and taught. Tacit knowledge on the other hand, is not as easily attained, but can be facilitated through social coordination i.e. activities where individuals in different organizations socialise, creating common norms, social bonds and trust. The mentioned activities should enable transfer of tacit knowledge, thus creating an intersection of different expertise that can lead to knowledge development.

By engaging in knowledge capture and knowledge diffusion the new knowledge may become relevant. Social coordination does not necessarily mean that the organization receives useful adaptations of the knowledge. This is because tacit knowledge that's transferred through human relations must be actively listened to by the actor (Bathelt, Malmberg, & Maskell, 2004), which entails capturing, translating and diffusing it to the members in the organization or network (Andersen et al., 2004).

4.2.6.2 *Coordination*

If the knowledge is not found within the focal company, the actor would need to search elsewhere to find this resource. This would lead to activities of finding suitable actors to cooperate with, and transaction activities with those. It is possible that more than one actor need to be approached, because the resources needed cannot be found in one place. In such a scenario, the focal firm needs to identify what resources exists and decide what type of relationship would be suitable with different actors based on their resources and capabilities (R. B. Handfield et al., 1999). In addition, connectedness between relationships should be considered due to their effects on an actor's relationship (Araujo et al., 1999; Håkansson & Snehota, 1995).

Activities connected to resource coordination are transaction activities such as resource integration, information processing, partner selection and risk and benefit sharing (Harland et al., 2004). These activities illustrate how resources are transferred between actors, thus creating an intersection of the resources, which may lead to knowledge development.

Resource integration connects two actors by integrating human and physical resources. Examples of integration of human resources is when personnel from one actor is loaned out and spends time with another actor. This activity has similarities with social coordination as presented in knowledge development, because the human presence at another actor encourages interactions at a personal level, thus creating an intersection of knowledge.

Information processing is about sharing information between network actors, such as information on price, cost, production schedule and demand. Furthermore, information processing can be facilitated through information and communication technology and is part of making the network more transparent. This activity is more linked to productivity enhancements than innovation, but is still a part of coordinating resources in that information is transferred between two actors.

Sharing risk and benefits are important to ensure that actors cooperate in joint development projects (Harland et al., 2004). Sharing of risk can be equal contribution in technology investments that yield benefit to both parties through joint ownership. Trust is crucial between actors in technological development as it can enhance the access to external actors' resources (F. Ian Stuart & David McCutcheon, 1996; Monczka et al., 1998). This is important as joint development requires interdependencies, and trust is necessary to manage these interdependencies successfully. Ensuring that all actors perceives benefit from the interaction may reduce the potential for a one-sided relationship where one actor enforces control over the other. One-sided relationships may lead to opportunistic behaviour. Such relationships, where one actor enforces control over adjacent actors are not compatible with the perspective of technological development because control is a barrier to innovation (Choi et al., 2001; Gadde et al., 2003).

Partner selection is the activity of choosing the correct actor to interact with. Based on the competencies that the focal actor possess, partners should be selected to complement these. It is critical with knowledge about the capabilities of actors which the organization interacts with to successfully integrate them in development projects (R. B. Handfield et al., 1999). With this knowledge actors must make an informed choice of partners in relation to what interface is desirable and how many partners should be involved (Harland et al., 2004; Monczka et al., 1998).

4.2.6.3 *Mobilization*

Resource mobilization is the process of internalising new knowledge and make resources available to perform learning activities. It is important that the right amount of resources is allocated to the right activities to ease the implementation, and to avoid excessive resource use.

In knowledge development, the organization need to mobilize resources that supports learning activities as well as knowledge diffusion and capture. Mobilization is about making internal resources available for different activities, mainly transformation activities. To internalise new knowledge the most prominent resources would be human resources as they are the ones who will adapt the new knowledge. However, new knowledge might also demand physical resources in the organization, which the learning activities will be performed on.

Resources are mobilized as a reaction to resource coordination due to the resources that are transferred through coordinating activities. The resources an organization mobilizes spans the three main groups of resources, namely physical, human and financial. The combination of these depend on the interaction, as illustrated by the interface model where it is apparent that the different interfaces demands different resources, and different amounts of them. Mobilization will be assessed in relation to what resources an organization disposition in development projects, both in relation to resources that are interfaced with actors and the resources that are dispositioned internally to capture and adapt knowledge that enters the organization. The focus of mobilization is on the internal aspect, but due to the interaction perspective of the thesis there may be a scenario where new knowledge is adapted to the organizations value chain through transaction activities. Thus, making it necessary to weigh mobilization in the external perspective as well.

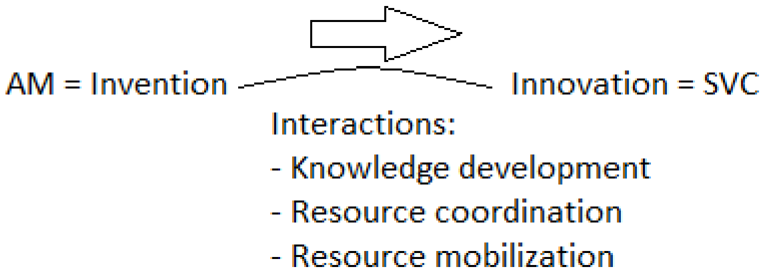

Figure 4.5 The hypothesised process of making use of AM to create shared value by using Håkansson's (1987) arguments for technological development.

The framework presented in this section is hypothesised to enable the implementation of AM through the arguments for technological development in networks. By viewing AM as an invention, interactions may turn it to an innovation by adapting it to an organization's value chain through resource mobilization and resource coordination with other actors to develop new knowledge. Figure 4.5 illustrate the process of implementing AM through interactions, with the output being AM as an innovation that in turn leads to SVC.

4.3 Shared Value Creation

The following chapter focuses on shared value creation, which is a framework to guide businesses on how to create value, not only for shareholders, but for stakeholders as well. The focus of this thesis is interactions and relationships in the supply chain, and theory from the field of green supply chain management, sustainable supply chain management etc. will embellish on the shared value concept.

4.3.1 SVC – the avenues.

Shared value creation is a framework that looks at competitiveness with a non-traditional view. The idea for this framework was first introduced in Strategy and Society (Porter & Kramer, 2006), and refined in Creating Shared Value (Porter & Kramer, 2011). Porter and Kramer argue that traditional views on how business works does not comply with today's business environment. Specifically, the critique is that businesses focus to much on short term monetary gain, e.g. the shifting of activities to countries with low wages. This short-term focus is met with civil society and governments imposing taxes and legislation that forces businesses to address social weakness. This scenario creates a notion that there are trade-offs between doing good and making profit. SVC is about blurring out these perceived trade-offs with a framework that combines the concepts of profit and corporate social responsibility (CSR) into the concept of creating shared value. The argument, is that in order to do good by the environment and society, a value principle must be used. Value is defined as benefit related to cost, and SVC's philosophy is that by employing a value concept, business and society will work on equal terms, which result in more effective achievement of objectives (Porter & Kramer, 2011).

Creating shared value takes place on three avenues; Reconceiving products and markets, redefining productivity in the value chain, and enable local cluster development. The three avenues are interconnected and must be seen in relation to each other. Enhancing activities in one of the avenues, will create opportunity in one of the others. Shared value is not about doing different environmental and social projects, but about undertaking projects that can be directly connected to the value chain of a business.

4.3.1.1 *Reconceiving products and markets (Porter & Kramer, 2011)*

In advanced economies, there is a growing focus on products with environmental and/or social characteristics (Laroche, Bergeron, & Barbaro-Forleo, 2001). For example, cleaning products should have chemicals that are non-harmful/allergy friendly and food should be grown ecologically and generally be healthy. Compared to more traditional ways of doing business, where taste and volume is more important, this defines a new type of demand. Customers are more environmentally and socially conscious, which means that businesses must start to ask themselves the question: Is our product good for our customers? Thus, companies must reconceive their products (Porter & Kramer, 2011).

Reconceiving markets is about realizing potential in markets that has not yet been utilized. Some are hard to reach because of poor distribution lines and others are not perceived as attractive enough. These markets are often characterised by a poor population, and can be found in developing countries as well as developed ones. Another characteristic is that the size of this population is big, which means that there are a lot of potential customers. One can divide the markets into two groups. First, the developed world, where a business can ask if the products they are delivering are good for the customers. For example, creating healthier food options or products that save electricity. Second are the markets of undeveloped countries, or the extremely impoverished areas of developed countries. These markets are quite interesting, because they represent an untapped market with a large combined purchasing power. These markets also need to be serviced, in that they need financial services, health services and information services. By providing products and services tailored to the specifications required in these markets a company is reconceiving it (Porter & Kramer, 2011).

Reconceiving products and markets are the first step to creating shared value for a company. On this level, a company must identify the social and environmental impacts inherent in their products. Consequentially, organizations can make changes to their products that might give the company a competitive edge, or even discover new markets to sell their products. When altering a product, or deciding to service new markets, changes and opportunities will arise. Reconceiving a market is to identify social and environmental issues experienced by consumers, and address these through appropriate products and services. Thus, revealing an opportunity to reconceive products by altering them to contribute with social and/or environmental value for consumers. Some products must be altered to fit the market in question, for example taste preferences varies from region to region. At the same time, if a product is reconceived in a SVC manner it could also be beneficial for markets in other locations, thus revealing an opportunity to reconceive these markets.

4.3.1.2 *Redefining productivity in the value chain (Porter & Kramer, 2011)*

The value chain consists of the activities a company executes to create value, as well as activities supporting the value adding activities (Barnes, 2001). Every activity has some impact on the environment and society, and is affected by these issues (Porter & Kramer, 2006). Shared value creation proposes that productivity improvements in each of these activities will improve profits for the firm, and in addition have potential to enhance environmental and social performance. The following describes possibilities to create shared value by redefining productivity in the value chain.

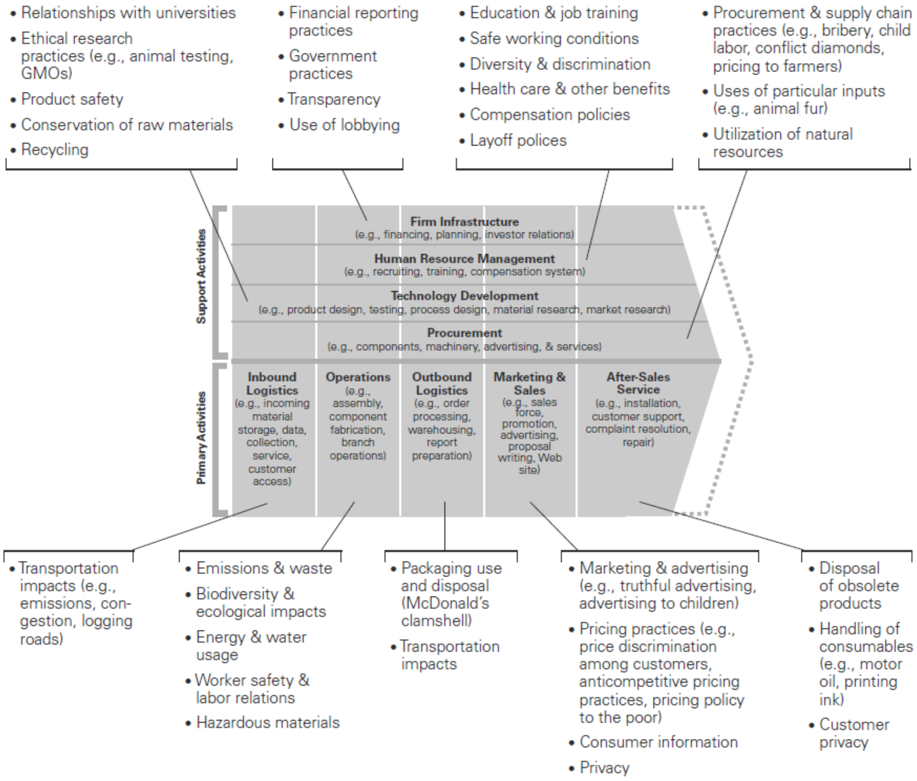

Figure 4.6 Porter's value chain with each activity's social and environmental impact reprinted from Strategy and society: The link between competitive advantage and corporate social responsibility (p. 8) (Porter & Kramer, 2006)

Energy and logistics. Energy use is a theme in most aspects of business, supply chain, distribution, processes, buildings and support services all require energy. Environmental legislation and rising demands for energy puts pressure on energy prices (Porter & Kramer, 2011). To cope, businesses may innovate technology, recycle, cogeneration etc. to improve their energy utilization. Especially, shipping is quite energy demanding, as well as it ads cost through complexity, lead times, inventory costs and management cost. Reducing shipping distances, and other steps that reduce the need to move cargo will create shared value by cutting the costs and at the same time reducing carbon emissions.

Resource use. Another aspect of redefining productivity is how a firm utilizes resources. Technology drives the possibility to utilize resources such as water, raw materials and packaging. Furthermore, recycling and reuse of resources might prove to be an effective way of utilizing resources. Depending on what quality of recycled materials, how expensive it is, and the resources (in this case maybe energy) used to recycle.

Procurement. Companies are focusing on commoditizing in situations where they have bargaining power, which leads to a focus on cutting costs in small businesses and subsistence farmers (Porter & Kramer, 2011). Outsourcing to suppliers in lower-wage locations is also frequently used. SVC proposes that marginalized suppliers cannot remain productive, and will have difficulties sustaining or improving quality. This also affects a supplier's environmental impact, in that a strong supplier often has a lower environmental impact. SVC focuses on supply base continuity to boost productivity in procurement, which can be achieved through technology sharing, increasing access to inputs and financial help. It is also pointed out that outsourcing creates transaction cost and inefficiencies that can offset low wages and input cost. By using more local suppliers, and focusing on developing them can reduce cycle time, increase flexibility, foster faster learning and enable innovation (Porter & Kramer, 2011).

Distribution. In SVC, distribution is about distributing products in a smarter manner, essentially, redefining productivity in distribution is about accessing hard to reach markets. As a result, society can benefit by getting access to lifesaving products like medicine, hygiene products, news and information etc. Additionally, it can provide work and opportunities for other business in these areas.

Employee productivity. Employees are a driving force behind value creation, and SVC recognizes that a living wage, wellness, safety, training and opportunities for advancement has a significant impact on productivity. Keeping costs down by cutting in salaries, health and wellness programs and outsourcing, might save money, but it will result in lost employee productivity. Reducing employee benefits might result in: lost workdays due to sickness, retraining of personnel and low productivity due to morality issues.

Location. SVC considers the notion of "location doesn't matter". This notion came to be because logistics are inexpensive, information flows easily and markets are global (Porter & Kramer, 2011). With carbon emission prices rising and the inefficiencies connected to outsourcing it is possible to boost productivity by sourcing locally. There are some benefits to this, first, proximity with suppliers and customers can reduce logistics cost by reducing fuel consumption. Second, the ability to restock in smaller quantities can reduce the cost of keeping stock.

The above efforts are mutually reinforcing in that improvements in one activity may reveal opportunities in others. For example, by using local suppliers you touch the location effort, as well as it helps improve the energy and logistics effort. At the same time this focus gives the opportunity to have a closer relationship with suppliers, touching the procurement effort as well. Different organizations will find not all efforts apply equally to them, and it’s important to focus on those efforts that have the greatest impact on their product and value chain. Figure 4.6 illustrates the value chain and various impacts different activities have in a social and environmental perspective, and can be used by organizations to evaluate their position in relation to measures that would create shared value in their context.

4.3.1.3 *Enabling local cluster development (Porter & Kramer, 2011)*

The third avenue of shared value creation is enabling local cluster development. The definition of a cluster in SVC is a geographic concentration of firms, related businesses, suppliers, service providers and logistical infrastructure (Porter & Kramer, 2011). Organizations within a local cluster may draw advantage of public assets such as schools and universities, water, market transparency and quality standards. Deficiencies in the cluster will result in lower productivity and create cost for the firm. For example, poor education results in extra training, poor transportation infrastructure raises the cost of logistics and discrimination diminishes the pool of available employees. Businesses can create shared value by addressing gaps and deficiencies in the local cluster. The success of a cluster spills over as success for the community by creating jobs in supporting industries.

When engaging in cluster development activities, organizations need to identify gaps and deficiencies in the cluster. For example, logistics, suppliers, distribution channels, training, market organization, and educational institutions. Additionally, it is important to identify which of these has the biggest impact on the firm’s own productivity. Some of these, the company will be able to engage themselves, and others are better suited as collaboration projects. Improvements that result in big impacts on the cluster should be performed through coordination with other actors in the cluster (Porter & Kramer, 2011). Such intervention in the cluster may have positive impacts, but are also difficult to implement due to the resources such joint ventures consume. To cope with different barriers an organization may encounter when creating shared value, a framework has emerged. This framework is called the collective impact and considers an approach for improving the previously mentioned dimensions of a cluster that involves multiple and non-traditional actors. The collective impact is thoroughly presented in section 4.3.3.

4.3.2 The interconnectivity of the three levels

The following section discusses the interconnectivity between reconceiving products and markets, redefining productivity in the value chain, and enabling local cluster development. The discussion is based on logistics to illustrate how a product can be reconceived, and how this relates to productivity in the value chain, as well as enabling local clusters, which can be linked to network activities.

There is a trend that the environmental cost of logistics should be internalized in products (Heiko A. von der Gracht & Inga-Lena Darkow, 2016). Thus, making it imperative to consider impacts of a product in the design phase. This indicates that focusing on logistics and energy use is important when reconceiving products, e.g. relating to location of raw material suppliers. A different possibility is to design products that support reversed logistics. That is, establishing a system where products can be returned to the producer, to be recycled, remanufactured, resold or thrown away. Reversed logistics can have sustainable connotations in that it shares activities that are applied for green logistics such as recycling (Rogers & Tibben-Lembke, 2001). In addition to creating environmental value it creates value for customers because a liberal return policy reduces the transaction risk for customers (Rogers & Tibben-Lembke, 2001). There is however an issue with what to do with the returned products. Reuse or recycle is demanding because to put the product back into circulation it needs to maintain quality and cost standards of new products. There is also an issue with the energy use of recycling because this can exceed that of new products. From this, it’s evident that different activities an organization performs are affected, thus opening for redefining productivity in the value chain. For example, organizing logistics in a way that reduce energy use, or focusing on procurement of raw materials that better fit with the chosen method of handling the returned products. To overcome these issues, an innovative capability is required, which may be facilitated through the avenue of enabling local clusters due to the innovative milieu that exists in local clusters (Dicken, 2011).

Markets that are not serviced poses a social issue, and a potential opportunity for companies who can successfully reconceive these markets (Porter & Kramer, 2011). If a company discover an opportunity to reconceive a market by servicing it with an appropriate product, opportunities will reveal itself in questions about productivity. For example, the distribution activity in the value chain. How you distribute is important, but also how far reaching your distribution network is, impacts a company’s productivity. Especially if the markets to be reconceived are located in hard to reach areas like undeveloped countries (e.g. rural India).

Because of the location, these markets might require energy demanding logistic operations to be serviced. A future scenario is that local markets like these will be serviced by smaller and more dispersed production facilities (Heiko A. von der Gracht & Inga-Lena Darkow, 2016). These facilities will need to be supplied, thus creating a demand for local suppliers to offset the logistics cost and create shared value. However, this may reveal challenges related to an efficient workforce, because these markets might lack certain skills required to operate these facilities. Some places might lack education, especially for women. Thus, a focus on training and education is important to raise the overall competence in the area. This can be achieved through cluster activities, where actors cooperate with local government or other actors who wants to access the market in building infrastructure and educational institutions. Actors in the cluster can engage in lobbying relationships and together put pressure on local governments, and through this achieve the wanted effect in the cluster by pressuring and investing together (Meyer & Wit, 2014). Distribution is also connected to packaging, which is a source of environmental issues because of the material it uses, especially regarding plastic waste. This gives an opportunity to redefine resource use based on what type (recyclable or not) of packaging, and how much packaging is used.

4.3.3 Ecosystem of SVC – Collective impact (Kramer & Pfitzer, 2016)

Following the release of Creating Shared Value (Porter & Kramer, 2011), a new view on barriers and how to overcome them has emerged in the article The ecosystem of SVC (Kramer & Pfitzer, 2016). The ecosystem of SVC (ESVC) emphasise that no company can work in isolation, especially while trying to create shared value due to various barriers. Three main barriers to creating shared value are mentioned in ESVC. First, a company is more likely to be feared than trusted, thus they might lack the legitimacy to initiate such a project. Second, companies who engage in collective impact improves market conditions, not only for themselves, but also for competitors. As these projects require considerable investments, firms are reluctant to initiate them to prevent free riders. Third, the investment must be justified and this can be a problem due to the challenge it is to assess the gain from a changing ecosystem. In addition, the project competes with other projects for investment resources.

To tackle these problems a framework called The collective impact (Kramer & Pfitzer, 2016) has been introduced. The framework consists of five elements: a common agenda, a shared measurement system, mutually reinforcing activities, constant communication and dedicated "backbone" support from one or more independent organizations.

A common agenda is a shared vision for the project where the involved actor's interests and perspectives are incorporated to form the output of the interaction. Creating shared value emphasise that actors who are involved are not necessarily businesses, but also governments and other entities with a different perception of value. Thus, understanding and customizing the common agenda are important for successful change (Porter & Kramer, 2011). Likewise, in selecting suppliers to focus on green initiatives, it's important to convey the tacit aspects of the green strategy (Igarashi, de Boer, & Fet, 2013). The SVC avenue of enabling local clusters may support this because in a tight cluster, the participating actors builds a common schema (norms, values, beliefs, and assumptions) (Choi et al., 2001). A local cluster supports the transfer of tacit information called "local buzz", which appears through face to face contact between individuals (Bathelt et al., 2004).

A shared measurement system is important to determine the success of the project and formalise the common agenda (Kramer & Pfitzer, 2016). The collective impact is based on working with non-traditional partners such as governments, which is mentioned as important in sustainable supply chain literature (Pagell & Wu, 2009). This notion also hails from the original SVC framework (Porter & Kramer, 2011) and points to the importance of having a shared metric of value based on profit, environment and social sustainability to incorporate non-traditional actors.

Mutually reinforcing activities means doing complementary activities. This indicates that a diverse portfolio of participants is needed as well as the capability to choose the correct participant (Kramer & Pfitzer, 2016). The collective impact relies on businesses, as part of supply chains/networks, as capable in choosing and evaluating participants. This is in line with literature discussed on interactions in technological development, in that knowledge of suppliers capabilities are crucial in joint product development (R. B. Handfield et al., 1999). Håkansson (1987) supports this and mention that it is important in technological development to be able to access the correct resources and perform the right activities to achieve project success. The collective impact uses these principles, but have an expanded scope of actors in that there is a focus on incorporating non-traditional partners.

Constant communication refers to frequent and structured communication. This element is meant to build trust and coordinate activities. The importance of communication is to build trust between the non-traditional actors, thus ensuring that they follow through on their commitments. Communication can be performed by scheduling seminars, individual updates on progress, events and workshops where actors participate in learning and informing each other of efforts and achievements.

"Backbone" support refers to a separate independent staff tasked with guiding vision and strategy, support activities, establish shared measurement practises, build public will, advance policy and mobilize resources (Kramer & Pfitzer, 2016). The Backbone organization is what holds the project together, and cannot be a company, since they are not neutral players.

The reason ESVC is important is due to the size of projects that change the ecosystem, which requires multiple actors. A requirement in these projects are interactions, which indicates the importance of cooperation in creating shared value, and may be relevant for technological development in this thesis.

4.3.4 Sustainable supply chain management in relation to SVC

This section discuss literature on sustainable supply chain management and its relation to SVC.

4.3.4.1 *Managerial involvement and strategic alignment*

For a company to become sustainable it is important that the organization has a sustainable mind-set. Managers need to convey the importance of sustainability by having a managerial orientation towards sustainability and incorporate sustainable goals to be compatible with monetary goals (Pagell & Wu, 2009). To have success with an environmentally sound supply chain, the decisions must come from corporate. By integrating decisions regarding environment into the supply chain, trade-offs between being environmentally friendly and being profitable becomes obscured (R. Handfield, Sroufe, & Walton, 2005). Being environmentally conscious may even provide competitive advantage, thus drive the profitability because environmental and social resources, such as knowledge (tacit knowledge) are difficult to replicate (Craig R. Carter & Dale S. Rogers, 2008).

The importance of a business being competitive is very important because a business who is not profitable cannot be sustainable (Pagell & Wu, 2009). In a supply chain perspective, this means that focusing on traditional best practises is still an effective way to start being sustainable and creating shared value. To be environmentally and socially sustainable, investing in human capital is suggested to be one of the best tactics by logistics managers (Murphy & Poist, 2002). Investing in employees is also an activity in lean management because it engages workers in problem solving, and thus create a more economically sustainable environment. In fact, many activities in lean improvement correlates with sustainable improvement, such as waste management, transparency, close supplier relationships, local sourcing and supplier auditing (Piercy & Rich, 2015). Transparency and supplier auditing are activities in vertical coordination, which is pointed out as an important impetus for sustainability and a foundation for economic sustainability (Craig R. Carter & Dale S. Rogers, 2008).

4.3.4.2 *Resources and relationships*

In Porter and Kramer's (2011) article Creating Shared Value, the authors mention supply base continuity and how this is a part of being more socially viable. By ensuring continuity in an organization's supply base through decommodization, transparency and supplier development the supply chain can thrive (Pagell & Wu, 2009). Engaging in these activities may secure an organization's contribution to SVC through social sustainability, but also by incorporating environmental criteria that reduce environmental impact in the supply chain (R. Handfield et al., 2005). A financial perspective also suggests a strategy of continuity when organizations are dependent on external resources. This view is particularly supported if risk and uncertainty is connected to the resources, and suggest engaging in vertical coordination to secure access to important resources (Craig R. Carter & Dale S. Rogers, 2008).

It can be argued that the view on suppliers in SVC is too simplistic. The notion that having close relationship with suppliers will bring benefits is true, but there are other aspects to consider. First, there is cost associated with initiating and maintaining a close relationship with a supplier (Gadde & Snehota, 2000). The cost could off-set the benefit that you gather from a relationship, and thus degrading the shared value created. Second, different levels of relationship with a supplier provides various outcomes in the form of productivity and innovativity (Araujo et al., 1999). Thus, being too closely connected to certain suppliers would lower the wanted outcome in either productivity or innovativity, resulting in reduced SVC.

4.4 Analytical framework based in literature

The following section presents a framework consisting of the topics that have been discussed in this chapter, namely additive manufacturing, interactions and shared value creation. The purpose of the framework is to be able to analyse findings from the case in relation to the research questions, and is derived from the initial hypotheses in the thesis. The section starts with a discussion of the interconnectedness of the main topics in this thesis and culminates in a three-stage framework.

Four assertions can be made based on the initial hypotheses and the literature presented in this chapter. The assertions relate to the research questions and the main topics:

- Interactions enable AM to be implemented into the value chain by providing arguments for technological development.
- Additive manufacturing creates shared value by redefining productivity in the value chain
- Additive manufacturing creates shared value by reconceiving products and markets
- Interactions create shared value through arguments of technological development and innovation.

These assertions form the basis for the conceptual framework. The purpose of the framework is to illuminate the research questions by analysing the implications AM has on a company's value chain and the interactions a company does in the process of implementing AM.

The following discussion is divided into three sections based on the assertions. First, considering the implications of implementing AM and how the arguments for technological development in a network might impact on the implementation process. Second, the impact AM technology have on SVC. Third, interaction as defined here is compared to the ESVC model to assess the case company's development project and its potential impact on SVC.

4.4.1 Interactions effect on AM

The ultimate output in this model is technological development where technological development is the implementation and use of additive manufacturing in a way that creates shared value. Table 4.4 describes the conceptual framework for how interactions in networks may enable the implementation of AM. Notice that its structure is based on Cousin's (2007) model for describing relationships.

4.4.1.1 *Strategic alignment*

The first stage of the framework addresses the implementation of AM and how interactions can be supportive of this activity. Interactions are based on the model for technological development and the arguments provided in Håkansson (1987). In this regard, implementing AM is viewed as the technological development, and thus the output of the interaction (relationship). The output must be connected to a focus on raising value through higher quality, lower cost etc. Quantifying the output of the interaction through such measures will enable the assessment of AM in relation to competitive advantage i.e. if it supports the competitive position of the company. This is essential for two reasons, one, cooperative development projects are resource intensive, and two, AM has a variety of implications and characteristics that affect the organization and may influence competitiveness differently depending on how it's used. The implication of cost is especially important to consider because a clear vision for the implementation can reduce the risk of the investment. Examining parts fit for AM can give an indication of what benefits AM can provide to an organization. As discussed, AM technology are proficient at manufacturing for variation and customization, complex structures and support the production of innovative products.

4.4.2 Purpose and place in Value chain

Literature and examples from industry indicates that AM can serve different uses in a company's value chain. Exploring these, and finding a use for it will demand resources being mobilized towards learning about application and the possibilities of AM. Because of the multitude of possibilities AM demonstrate, the outcome of resource mobilization is correlating with the amount of resources being mobilized, what resources being mobilized for this purpose and what knowledge are already present in the company.

Implementing AM will affect the different activities in a company's value chain. Some activities will be performed differently, and new aspects will be introduced in some activities. The process of AM indicates that there are many steps involved in making an AM part including part design and post processing. These steps will affect the operations activity and the technological development activity and are examples of activities that must be considered when implementing AM. The change in activities will affect how resources are utilized and demands novel resources to be introduced. This implication introduces the arguments for technological development in that a company must mobilize resources to handle the impact of the invention. The impact of AM will also require new knowledge, which leads to the argument of knowledge development. The assertion that interactions make AM possible are derived from the notion that AM requires new knowledge in various aspects of the value chain, thus an organization may benefit from information channels from its network and coordination of resources with other actors.

4.4.2.1 *Interfaces*

To develop the new knowledge, the organization must gain access to the necessary resources through relationships with other actors. Thus, necessitating engagement in transaction activities in the network to coordinate resources and assessing what relationships they can exploit. These relationships are inputs to the process as they provide access to different resources, which lays the foundation for knowledge development. Depending on the purpose of AM in the value chain the interface with these actors may differ, as this decides the level of innovativeness that are necessary for the company. However, in the perspective of the thesis an interactive interface is likely to be favoured due to the focus on innovation.

Table 4.4 Input/output model of technological development with respect to AM.

Input	***Process***	***Output***
AM Internal resources External resources Relationships	Knowledge development Resource coordination Resource mobilization	Technological development (AM)

4.4.3 AMs effect on SVC

The second purpose of the framework is to assess the impact AM can have on SVC. This section approaches the implementation of AM from a shared value perspective. When an organization assesses if AM is suitable to their competitive position and its purpose in the value chain, the implications and characteristics of AM can be viewed in relation to the avenues of SVC, especially pertaining to reconceiving products (and markets), and redefining productivity in the value chain. AM is already being used to add value to certain products and processes, as exemplified in 4.1.4. To create shared valued, this model proposes to view the benefits and limitations in relation to the avenues of SVC as depicted in Table 4.5.

Reconceive products and markets

AM can manufacture features in a part that is not possible with subtractive technologies, which is a characteristic that can be an important driver in reconceiving markets and products. The characteristics of AM provides the opportunity to customize and quickly redesign products, which makes it possible to serve markets with different standards and needs. The design freedom can also be beneficial in reconceiving products to be more environmentally friendly. Essentially, a company should explore if AM can help make products beneficial beyond materialistic considerations for their customers, or if AM can help serve markets that are not currently being served.

Redefine productivity in the value chain

The literature review reveals that AM possess characteristics that could enable the avenue of redefining productivity in the value chain by promoting design freedom and less material usage. It is also important however, to be cautious of the limitations of the technology. SVC is about creating shared value, which includes profits as well as environmental and social value. This means that a firm should also be aware of the limitations in AM technology, and align the choice of implementing AM for SVC purposes with overall competitive strategy.

Table 4.5 Input/output model of AM creating shared value

Input	***Process***	***Output***
AM with benefits and limitations	Reconceive products and markets Redefine productivity in the value chain	Shared Value

4.4.4 Correlation between interactions and SVC

The elements of ESVC are closely connected with elements describing interactions, which indicates that interactions support the implementation of a SVC framework. Below, these similarities are discussed for each of the elements in ESVC.

In a relationship, it was stressed that an intensive interaction should have a clearly formulated goal. This point can be compared with the importance of having a common agenda for the project. To be sustainable, the implementation of AM must be done on a strategic level by management. This is to ensure that value is created i.e. combining environmental and social goals with monetary goals.

To be able to assess the accomplishments of an interaction it was also mentioned that the output must be measured. This is also a consideration in shared value, because a key factor is that different actors should be able to perceive value creation for themselves. Both these points are important so all actors know what is expected from them and it helps building trust because a shared value measurement helps indicate if the project is successful for actors with different appreciation of value.

Mutually reinforcing activities in ESVC relates to the input and the process of interaction. This can be translated to the interaction process as different actors contributing with different resources in the input stage, and doing different, but complimentary activities in the process stage. Technological development requires the combining of different resources to create new knowledge, which is achieved through transaction activities performed by different actors.

Constant communication in ESVC indicates a close relationship and an interactive interface. However, this is not necessarily the only way to create value, as you gain more productivity from a less intensive interface.

Backbone support is not mentioned in the interactions framework because there is a difference between these types of development projects. In ESVC, actors are more concerned with incorporating non-traditional actors to change the ecosystem in which they do business, which are easier for free riders to exploit. Whereas technological development is focused on ecosystems on a smaller scale e.g. between a buyer and supplier. However, backbone support is mentioned in the framework because this opens for larger scale development projects, incorporating government, research institutions and other entities that have other measures of value than industrial partners. Consequentially, this can reduce risk for participants and may dissolve unhealthy power struggles.

Since ESVC and the framework for technological development possess similar traits, it indicates that interactions, as described here, can support SVC. Thus, by combining concepts from the ESVC and interactions it’s possible to incorporate environmental and social considerations in technological development.

4.4.5 The conceptual framework

The discussion above outlines the elements of the conceptual framework, and these are distilled in the following steps. The conceptual framework imitates a simple implementation guide for AM and is meant to facilitate discussion about findings in the analysis.

1. *Strategic fit in the context of competitiveness*

In this stage, the characteristics of AM are considered related to competitive positioning of the case company. This will relate to the characteristics and implications of AM and if this technology is an opportunity for the case company.

2. Application

The second stage of the framework discuss the purpose of AM in relation to its impact on various activities in the value chain. In addition, the impacts on activities are examined in relation to the avenues of SVC.

3. Interactions and ESVC

The third stage considers what role interactions play in the implementation of AM. Consequentially, facilitates discussion about the findings with consideration to resource coordination, resources mobilization and knowledge development. In addition, the findings are discussed in relation to ESVC to determine if the case can be deemed a project that creates shared value.

The proposed framework contains aspects from literature that will be taken into consideration in the analysis. Table 4.6 presents an overview of the points that are to be considered when analysing the case, and are connected to the three main topics of the thesis.

Table 4.6 The main elements from theory that are relevant in analysis

Topic	***Elements from theory***
Technological development	Knowledge development Resource coordination Resource mobilization
Implementing AM	Competitive strategy Implications of AM Possible uses for AM Benefits and limitations
SVC	ESVC Avenues of SVC

5 Case

The case describes technological development in Plasto AS, an injection moulding company from Norway. This section describes Plasto and their relationship with AM, from their experience with rapid prototyping as a supporting technology and their thoughts about the future of AM. The following presentation is based on interviews with key personnel at Plasto, visits at their firm's location and documents such as industry journals and project reports.

5.1 Plasto

Plasto is an injection moulding (IM) company located in Åndalsnes, Norway, which is a small town with roughly 2200 inhabitants. The town lies in Romsdalsfjorden at the mouth of the river Rauma and is encircled by mountains. The company is 100% family owned divided ca. 50-50 between two brothers. Plasto has been family owned through three generations since its founding in 1955.

Plasto regards SVC as sustainable development. When talking about shared value in practise they view it as interacting with other actors to create value together. Plasto is currently engaged in a project with AKVA group where the goal is to achieve a closed loop on raw materials, returning materials to its original state at the end of a product's lifetime. Plasto is also looking at the possibility to position themselves with product offerings in relation to an aging population. In this regard, they are looking at products that can help give a more effective treatment of elders. This project is however in its earlier phases, meaning it's only a vision for the future. Plasto's work with sustainability is focused downstream in the supply chain.

5.1.1 Strategic positioning

Equipment used in the IM industry is standardized and easily obtainable, so most actors compete on cost leadership. Plasto is operating in Norway, which results in high production costs due to high salaries, thus making it difficult to compete with IM companies in low cost countries. Plasto has taken a position of differentiating their processes, producing more specialized products that are knowledge demanding.

Plasto's competitive position is enforced by focusing on knowledge, distributed between the knowledge of those who work with development, and those who work in the process. The development team works with constructing the best possible mould, while process use their knowledge to identify the correct parameters to produce a product per the specifications. Plasto's knowledge about tools are extensive in that they, in addition to design, have a workshop where they can do alterations on tools when there is demand for it or there is an error with the mould upon delivery from tool suppliers.

5.1.2 Network

To substantiate their position Plasto rely on using their network to acquire knowledge. They are engaged with research institutions through different projects, and are a shining example of a firm who uses public research grants in development projects. Plasto have profound knowledge about their network and regards this as the largest value they bring into new projects. The network is also used to gain access to new markets and customers. Plasto does not invest in traditional marketing, but are introduced to new customers through research projects. Plasto either approaches a new potential client through a research project, or a research partner introduce Plasto as a solution if a potential client has a problem that can be solved by injection moulding.

5.1.3 Knowledge management

Plasto is a business based on knowledge, thus the participation in research projects is crucial to enhance the knowledge base. When participating in a development project, the project manager at Plasto receives reports at particular intervals with information about the progress on different work packages. New knowledge is shared within and between different departments. However, there are no specific routines to disseminate new knowledge.

Plasto works proactively on behalf of their customers in that they try to foresee changes in the marketplace caused by events such as new legislation. With new potentially disrupting changes, they work to gain knowledge on the subject to be able to supply solutions when demand arises. This particularly relate to changes in environment and social issue legislation. In relation to the AKVA group project Plasto are currently working to acquire knowledge about renewable materials and develop technology for this purpose. This is their way of being in front of what they believe will be important for this industry in the future as new policy on plastic waste might pose a challenge to the industry.

Plasto’s focus on R&D is tightly connected to their network. Plasto has a person located at SINTEF Raufoss Manufacturing AS. He is a connection between Plasto and the research environment on Raufoss. His function in Plasto is to be aware of technology or research projects that can be of interest to Plasto. He is also a link when Plasto is engaged in R&D projects that are publicly funded. These projects are bureaucratic in nature, and the research manager's responsibility is to secure quality in Plasto's contribution to the project partners and funding agencies.

5.1.4 Supply

Plasto's physical resources consist of IM machines, moulds (also referred to as tools), raw material and assembly technology. These resources have distinctive features related to supply risk and dependency.

The IM machines are easily acquired, and even though they are expensive, there is no apparent supply risk related to them. The reason for this is that there are multiple suppliers to choose from.

Plasto used to make their tools in-house. However, this activity had to be outsourced because it was not financially viable. First, tools were sourced from Europe, before Plasto started to have them made in China. The decision to use Chinese suppliers are because they are the most cost effective. Lately, due to rising cost in Chinese suppliers, Plasto has gone back to source from European suppliers in certain cases. European tool manufacturers sometimes hold more competence than their Chinese counterparts, and Plasto finds it beneficial to exploit this if they are experiencing technical challenges related to the tools. Furthermore, as Plasto has made clear, their technological development happens through interactions, and spatial closeness to suppliers enhances cultural closeness, which Plasto regards as important in technological development. Due to the wide selection of tool suppliers, they do not pose a risk in supply. However, the investment is quite capital intensive.

Raw material is in the form of plastic granulates. Plasto expect to spend about 30 million NOK in 2017, and are supplied by a few large multinational corporations. The access to raw material is very important to Plasto, and in times where the price is low, there seems to be a shortage of this resource from all the suppliers. This conceivable, but unspoken cartel practice harms Plasto and poses a supply risk for the availability of raw materials. Especially since Plasto is dependent on a few suppliers to deliver the product. In addition, due to the size of these conglomerates, Plasto's purchasing volume is small, resulting in zero power to leverage the suppliers. The project with AKVA group is aimed at reducing the reliance on raw material suppliers by reusing raw material.

5.2 Plasto and additive manufacturing

Plasto's relationship with AM is mostly with prototypes (using 3DP) that are used for communicating with customers and to convey and discuss ideas internally. The prototypes are used for development work, and are especially useful when the products are of considerable sizes.

5.3 Ekornes and the IC2 project

Plasto delivered a plastic component to the footrest of the Stressless chair produced by Ekornes ASA. The component was produced by IM machinery. It was discovered that the tool suffered abrasion and diesel effect, which gave the finished product an unwanted finish. Plasto's solution was to install cooling channels in the tools to vent out the air. However, this proved unsuccessful through conventional production methods. Through their research partner at SINTEF Raufoss Manufacturing AS (SRM), they became aware of a project called IC2 (Intelligent and Customized Tooling) and were invited to participate.

5.3.1 IC2

IC2 was a competence project that started in October 2010 and ended in September 2013. The total budget was 4,6 million euro, of which the European Commission (EC) contributed 3,2 million euro. The project was aimed at enhancing competitiveness of European tool manufacturers by developing innovative technologies that can reduce manufacturing cost, reduce lead time and reduce tool cost. The project researched technology related to surface treatment of moulds, surface embedded sensors and the deployment of a hybrid manufacturing cell ("Home - IC2," n.d.).

Hybrid manufacturing is the combination of additive and subtractive manufacturing methods to create higher value tools. The goal was to combine these methods to produce tools faster with higher precision, and combining this with the geometrical freedom of AM. AM was used to create tooling inserts, cores, channels and cavities in the tools. As these manufacturing technologies are very dissimilar, the vision was to create a manufacturing cell which would let CNC-milling and AM follow each other without intermediary operations. With hybrid manufacturing one of the main challenges was to decide what part of the product should be manufactured with CNC-milling and AM technology. IC2 solved this by creating an algorithm that analyses the CAD model based on geometrical complexity and decided which part should be made with AM. The software for hybrid manufacturing was developed by NTNU and SRM, and tested on Plasto's tool for Ekornes.

There were nine industrial companies, five European R&D institutions and two universities participating in the project. A project officer from the EC was appointed with the responsibility of keeping track of the formal parts of the project, such as milestones, progress, fulfilment of budget and that actors uphold their efforts.

5.3.2 Plasto's contribution to the project

This section describes Plasto's role in the project, including what resources they contributed with, what activities they performed and the level of communication.

Plasto participated with different resources and had a close relationship with other actors in the project. Communication between the participants was frequent and Plasto was in contact with some daily. Others they had contact with less frequently, such as weekly and when otherwise required. The communication consisted of meetings where actors discussed each other's cases. The different industrial actors had different issues to contend with, and Plasto participated in sessions where these issues were discussed and the actors could propose solutions. AM was introduced through these discussions by one of the research partners in the project.

From the organization, Plasto contributed with three people from the development department, two people from the tools department and three people from management. Plasto's production equipment was made available for researching the durability of tools. To test the solution, they used Plasto's ordinary production to gain statistical basis. There was requirement for some financial investment, but this was not of significant size. This was due to this being a EU project, which does not have an upper limit on the size of the financial contribution from public funds. Because of rules of competition, a Norwegian project with governmental funding has limits on the financial contribution ("Oversikt over regelverket - regjeringen.no," 2014). Public funds are a prerequisite in such projects to relieve Plasto of risk connected to high investments in technology development. The main contribution from Plasto was research and development and their production facility.

5.3.3 The solution

IC2 combined CNC and additive manufacturing so that they could work in synchronisation. The mould was first CNC-milled, then immediately further manufactured with AM. Plasto's invention of venting the air traps were implemented through a process that used the characteristics of AM to mount an insert with microscopic cooling ducts in the mould. These cooling ducts transported air and gas out of the mould, thus countering the initial problem of air traps, reducing cycle time in IM production and increasing tool life of 400 %. Consequentially, Plasto was able to produce the component for Ekornes with the right quality, thus reducing amount of rejected parts in production. The solution was used in full scale production with 220 000 units a year.

Plasto measures these projects on achieved reduction of cost and the improved quality of the product. Additionally, Plasto regards gaining knowledge as very important, especially knowledge about the network as this is the most valuable resource for the organization.

5.3.4 Learning about AM

Plasto acquired knowledge about materials, methods of building and strategies about AM from this project. Through this, Plasto realised that layered manufacturing technology require a diverse portfolio of knowledge to turn into AM. AM has previously been considered at Plasto, but not as a serious contender to IM because IM is more cost effective and delivers better quality to the products Plasto deliver. This view was challenged by the possibilities AM portrayed in IC2 i.e. AM can solve problems that traditional methods can't if used correctly. At a conference in Silicon Valley in 2014 Plasto was presented with the prediction that AM would make IM obsolete in 10 years. This notion was not perceived as threatening because they learned of the larger potential of AM technology through IC2.

Plasto does not currently use the technology that were developed in IC2, because current projects focus on larger components where the technology is not applicable. The technology is however accessible through partners from the project.

5.4 AM, thoughts about the future

As a production tool, AM can eventually be interesting to augment the production of customized products where it is not financially sound to purchase a mould for each part. The envisioned use of AM in this instance would be to produce the components that differentiate the products, while producing the core component with traditional IM technology. Another aspect of this is that when producing large components, the pressure in the mould is lower than with smaller components. It might be that AM produced components will be able to handle the pressure in larger tools, thus enabling more and larger parts of components in the mould to be produced by AM. Plasto views the performance of AM produced components as the main barrier, because of the pressure inside the mould. To put this into perspective, the largest machine they own produce a clamping force of 1500 tonnes. If, however, the performance of AM could be enhanced, Plasto would consider it positive to be able to print the entire mould due to the lead time of moulds currently being bought from China.

In SVC perspective Plasto believes that AM can be beneficial because it can reduce the amount of raw material used in tools production. This realisation is directly related to the IC2 project. In addition, this experience proved that AM can raise profits because of the positive impact it had on tools. However, cost of AM is still regarded as a barrier for Plasto.

6 Analysis

The following chapter presents the findings in the case in relation to elements from the theory, and discuss the case using the conceptual framework, which was presented at the end of the theory chapter. The chapter follows the framework's main points, namely interactions effect on AM, AMs effect on shared value and the correlation between interactions and SVC.

6.1 Elements from theory related to case

Table 6.1 shows an overview of elements from the literature and the connected findings from the interviews. The findings are divided in aspects relating to the case company and the case company's participation in IC2.

6.1.1 Technological development.

The first three rows in Table 6.1 are dedicated to the arguments of technological development and how the case company engages these.

The case company activate different departments in relation to new knowledge. The departments in question are tool design and process department. When technology or knowledge enters the organization, tools design and process adapts it to support the manufacturing of products. In the IC2 project these departments were activated in testing and developing the new solution. However, the interviewees responses differed in what degree knowledge from new projects are disseminated to different departments.

Interviewees put emphasis on the notion that development in the case company happens in interactions. The case company coordinates resources with customers, working closely with them in product development. The most prominent element of resource coordination is the participation in research projects. The case company is often engaged in research projects since it is crucial to their strategy to develop new knowledge, as well as alleviate the risk connected to heavy investments in technological development. Resource coordination is illustrated in these projects through human resources and physical resources being dispositioned at intersections with other actors in the project. In addition, financial resources are present at the intersection through public funding, which reduces risk connected to technological development. IC2 illustrated this with Plasto contributing with a variety of human resources from different departments, as well as physical resources in terms of production technology. Additionally, a point of interest is the human resources they permanently have at SRM who is constantly coordinated with the network and enhances the case company's knowledge about the network.

By coordinating resources with the research network and their suppliers of tools, the case company develops knowledge. IC2 shows how they, at the intersection of different knowledge, where able to create a new and improved tool using the case company's idea of venting air traps and combine it with AM technology. In addition, the interviews showed that new knowledge about AM technology were introduced into the company in the form of application knowledge and requirements to use the technology.

6.1.2 Additive manufacturing

The interviews revealed that the case company's competitive position is on differentiating themselves with knowledge intensive products and processes. They also rely on their network of suppliers and research partners to substantiate this.

AM could not be used to create end products because of cost and quality requirements. However, tools have such characteristics that make them compatible with AM technology, such as low production volume and custom design. However, AM poses barriers in the form of strength requirements. Because of the barriers, AM is not relevant today, but the case company have visions for the future. This entails using AM for variety, by producing components for larger builds with lower strength requirements. IC2 also showed how they can utilize AM's ability to create small internal structures in tools.

The interviews showed that the case company has contemplated the implications AM would have for them. These are listed in the table, and most notably was the possibility to use AM in tooling to shorten the lead times of tools, which are now sourced from China. The IC2 project taught the case company that AM requires a variety of skills and knowledge to implement, but that the investment can be profitable as proved by the outcome of IC2.

The case company regards AM as a technology with many possibilities, but are unsure of the benefit compared to the limitations of the technology. Most notably was the quality barrier of parts made with AM, since the use of AM would be implemented in the IM process. This would require the parts made with AM to withstand a tremendous amount of force inside moulds, and the case company did not believe this to be possible now.

An important aspect of the thesis is SVC, using the ESVC model to assess if projects are compatible. The table shows that there are aspects of IC2 that are concurrent with this model, such as having a backbone support in EC and the wide variety of actors who participated, thus ensuring mutually reinforcing activities. However, there seemed to be a lack of shared measurement, especially related to environment and social issues, which may degrade the shared value contribution considering the ESVC model.

Table 6.1 The main elements from theory and correlating points identified in the case

Elements from theory	***Findings in case***	***Relating to IC2***
Technological development		
Resources mobilization	Process/tools design R&D	Testing on Plasto's production. Disseminating project information in the firm.
Resource coordination	Research projects Product development with customers Working close with tool manufacturers on knowledge intensive products.	Invited by SRM Human resources in discussion groups Human resources in development Human and physical in testing. R&D at SRM
Knowledge development	Through network Research projects	Introduction of AM came through discussion groups AM: materials, building and strategies. Diversity of AM applications. Knowledge requirement for AM
Additive manufacturing		
Competitive strategy	Differentiating Knowledge intensive Utilization of network	
Parts fit for AM	Customization Low volume parts	Small structures.
Implications of AM	Lead time of printing tools rather than sending from China. Product design Communication	Need for variety of knowledge. Can raise profits as shown in this project.
Uses for AM	Prototypes Tools Components in larger builds Customization Variety	
Benefits/limitations of AM	Quality of parts because of high strength requirements in IM. Not as cost effective as IM Energy demanding Cost of AM is considered a barrier.	The new solution is not beneficial for large builds.
Ecosystem of SVC		
Common agenda		Reduce cost and lead time on tools
Shared measurement (value)		
Reinforcing activities		Cooperation between actors with different resources
Constant communication		Daily Weekly Otherwise required
Backbone support		Project officer EC

6.2 Applying the conceptual framework to the case

Table 6.1 summarize the findings from applying the concepts from literature to the case. The following section discuss these findings more thoroughly in relation to the conceptual framework presented in 4.4

6.2.1 Strategic alignment

Plasto is focused on producing knowledge intensive products. The characteristics of AM does not necessarily support all their products. For example, they are currently engaged with a customer for which they supply components that are 200 meters in circumference, which would be difficult to make with AM technology due to limitations in build sizes. However, the focus on knowledge intensive production gives them an incentive to explore the technology as the characteristics of the technology might prove useful in smaller or more complex products. The IC2 case proved this by utilizing the characteristics of AM in the solution, which would be difficult or maybe impossible with conventional manufacturing methods. The initial idea of venting the air traps through cooling channels was introduced by Plasto, but they lacked the necessary manufacturing capability to implement it. AM enabled this idea due to AM's capability of manufacturing microscopic channels directly on the tool. This illustrates AM's potential for a knowledge intensive company, in that it can add another dimension to what is possible to manufacture. Plasto's competitive position does imply that AM could be useful to them, not necessarily as a primary manufacturing technology, but as a supportive technology that lets them expand their position by offering enhancement to their products and processes. The interviews supported this, in that it was explicitly mentioned that Plasto does not produce anything that other injection moulding companies can easily copy and compete with based on cost. Plasto's experience with AM pointed to the technology being knowledge intensive, thus supporting their competitive position. By utilizing AM, they can substantiate their position, knowing that AM requires innovative capabilities and that the technology has larger potential than only producing complex components and finished products.

6.2.2 Purpose and place in the value chain

Layered manufacturing technology has been used by Plasto for Rapid Prototyping purposes related mainly to product development. It has also been used for sales and marketing activities due to the possibility to make miniature models of larger products. This makes it easier to travel and showcase these products at conventions or customer's location. Plasto have utilized printing models to quickly be able to visualise products for their customers and colleagues, and discuss them. Visualisation enabled by AM technology has been discussed as something that can benefit SVC (Sletfjerding, 2016) through reconceiving products by creating an environment where the product can more easily be discussed between actors. The value chain can be effected positively by more efficient product development. The tools Plasto procure are capital intensive, and by raising the certainty of design they can reduce the chance of ordering tools with defects caused by mistakes in this activity.

In the IC2 project AM was used in the operations activity, namely in producing tools for their process. There's a significant difference between using AM for producing the finished product and producing the tools. Literature suggested that AM are best suited for low volume parts, but by using AM in tool manufacturing, one could circumvent this criterion. When producing the tools, Plasto managed to take advantage of dimensions that are unique to AM, resulting in a higher quality tool with more efficient longevity.

Plasto does not currently use the technology, but the purpose and place in the value chain described here has provided benefits to Plasto's production. These benefits are summarized in Table 6.2. Considering the competitive position of Plasto, utilizing AM to enhance tools makes sense due to tools being a main source of value capturing in Plasto's value chain. However, AM is not currently utilized in the operations activity, but a purpose and place in the value chain has been discovered and may be explored through procurement activities were suppliers of AM and tools will have a crucial role in the future. In addition, using AM for rapid prototyping purposes have proven beneficial to the value chain through visualisation in product development and marketing activities.

6.2.2.1 *Redefine productivity in the value chain*

The purpose of AM in the value chain has implications for the productivity in various activities. The main driver in this regard is that the tools now live four times longer. This reduces the need to purchase new moulds at certain intervals, which have numerous benefits to SVC-productivity, illustrated in Table 6.2. First, this reduces raw material use by how much raw material it takes to build a new mould. In addition, the reduction in procurement of new moulds saves energy in the form of transportation, which is especially pertinent in cases where new moulds are sourced from China. These points also have a cost aspect, because they need to purchase less moulds, and due to the technology being sourced in Europe, the lead time for these moulds are reduced. If moulds bought in Europe can be as cost effective as those purchased from China, this would enable even more avenues of shared value creation in the form of more local sourcing, supplier auditing etc. The problem with the old tools was that they became worn, which resulted in parts that weren't usable and would have to be remelted. The new improved tools produce with higher quality, thus saving Plasto for this extra labour, which demands energy and time, making the process more profitable. Raising the profitability of tools may offset the reduced cost in Chinese suppliers, thus enabling more sourcing from more localised suppliers.

Table 6.2 Overview of Plasto's use of AM technology and benefits gained from the technology

Plasto use of AM	*Benefit*	*SVC aspect*
Rapid prototyping	Visualisation	Less mistakes in PD
Tool manufacturing	Higher quality tools Higher quality product Longer lifespan of tools Knowledge intensive	Less scrap in production Localisation of supplier Profitability Logistics (shorter lead time)

6.2.3 Interactions

The following section analyse how AM was implemented in Plasto's processes by interacting with other actors in the network. The essential elements of this discussion are Plasto's resources and how they were coordinated with the participants in the IC2 project. In addition, how Plasto's resources are positioned on a regular basis to make use of their network to gain and create knowledge. The discussion is based on the arguments of technological development and on the requirements of ESVC.

6.2.3.1 *Resources Coordination*

Research manager

Plasto are continuously present at SRM through their development manager who is located at Raufoss. He is constantly coordinated with the research environment at SRM since he is also employed here, and is part of Plasto's connection to the network. This has several benefits, first, it counterbalances Plasto's remote location, giving them a connection to the cluster at Raufoss and still lets them have most of their resources located in Åndalsnes. Second, he keeps Plasto's knowledge connected with that of the research cluster, thus enabling knowledge development. Third, being closer to SRM also puts him in contact with the expanded network of the cluster supporting Plasto with information about projects and innovations. Plasto was invited to be part of the IC2 project by SRM. Hence, he is the enabler of the latest information being transferred to Plasto, keeping Plasto's knowledgebase updated, which is important due to Plasto's competitive position of innovation and knowledge intensive products.

Human resources

In perspective of the IC2 project, Plasto sent human resources from different departments, namely tools, management and development, to participate and discuss their case with other actors. These departments have separate tasks within the organization, and thus have a diverging knowledge base. Coordinating human resources from different departments may give internal benefits as knowledge development in interactions happens based on different knowledge. Through interactions, human resources were coordinated with experts from other actors, both industrial actors and research partners. First, they shared their knowledge by discussing each other's cases, which gives Plasto a source of knowledge that can be applied to their internal problem. Other actors will have different views on how technology can be applied, what technology can be applied and may even have similar issues where they have failed, thus providing information on what doesn't work. Plasto's broad presence might also be beneficial in that they have a bigger chance of connecting socially with more of the other actors, creating weak ties. On the one hand, these sessions with brainstorming transfers explicit knowledge. On the other hand, it's also an arena where they build common schema and cultivating an environment for transferring tacit knowledge, which are imperative to create an innovative milieu.

Physical resources

The knowledge Plasto gained about AM through IC2 was also due to their coordination of physical resources. Plasto used their production technology in testing, and coordinated it with their partners who contributed with CNC-machines and AM equipment. Because Plasto were the ones with the idea with the venting technique they played a part in designing the finished mould, which gave them access to AM resources and would give them more information about design for AM.

6.2.3.2 *Resources mobilization*

Plasto generally mobilize resources in two different departments, namely tool design and process. Human resources from these departments are activated when new knowledge enters the organization in the form of specifications for a new product. Output is created by mobilizing human resources in these departments to adapt the specifications into a product that fit their processes. In addition, Plasto mobilizes human resources in developing automation technology for their processes. This department is coordinated with process and tools to develop new knowledge about how they can best produce the product with minimal human interference.

The technical and practical challenges to the new solution in IC2 were resolved in collaboration between an employee at Plasto and researchers at NTNU and SRM, using Plasto's production equipment. Firstly, this illustrates how both human and physical resources were coordinated with different actors to create new knowledge using AM in Plasto's production. In addition, when testing the solution in Plasto's production, the process department were involved in configuring the right parameters, which is an example of internal mobilization of resources where they perform transformation activities, learning to apply the innovation in everyday processes.

6.2.3.3 *Knowledge development*

Coordination of resources contributed to knowledge development that benefited Plasto theoretically and practically. This knowledge was largely related to application knowledge for AM, but also about materials and the process of AM. They found that AM are not a technology you can start using without preparation, and that it needs a variety of knowledge. The revelation of this fact about AM gives Plasto a more realistic view on the application of AM, as well as preparing them for a situation where they want to utilize it because now they have knowledge about what resources they need. In addition, their participation contributed to development of knowledge in the process of AM in relation to the production of the tools.

Tools are important for Plasto and is reflected in that they have a lot of knowledge about tools which they mobilize in development projects. However, they have persisted in sourcing this from China, even though this interface has little or no benefits to innovation, and have instead focused on productivity gains with respect to cost. In the IC2 project, the interface with tool suppliers are much different in that they have worked closely with them through discussion groups where they exchange ideas and discuss solutions. In addition, other examples of using European suppliers have culminated in knowledge development through coordinating Plasto's knowledge with other actors to gain knowledge about tools or the network. This shows the benefit to innovation from closer relationship with their suppliers because of the closeness in geographical spatiality and cultural spatiality. In contrast, the use of an agent, like they use in China, offers little closeness, but ensures low cost and the profit gain from this.

It is difficult to separate the processes of resource coordination, resource mobilization and knowledge development due to their interconnectedness, which results in overlapping. The above discussion illustrates this, especially in how human resources were both part of interacting with other actors, thus coordinating resources, while simultaneously being mobilized internally to adapt and test the solution on Plasto's process. The discussion attempts to discuss the arguments of technological development separately, and the main points are summarized in Table 6.3.

Table 6.3 Arguments for technological development in IC2

H = Human, P = Physical, F = Financial

Argument	***Resource***	***Activity***
Resource mobilization	Tools department (H) Process department (H) Production technology	Testing in production
Resource coordination	Tools department (H) R&D (H) Process department (H) Production technology (P)	Communication Discussion groups Product testing Product development Social coordination
Knowledge development	Combination of AM and traditional method Knowledge about using AM	Knowledge capture

6.2.4 ESVC

This section presents the IC2 project considering the ESVC framework. Table 6.4 summarize aspects of the project that are connected the ESVC framework.

A common agenda/shared vision – Clearly formulated goal for the output

It is in Plasto's interest that tool manufacturers have knowledge about making higher value moulds, which is evident from the importance of mould design in Plasto's products. This creates an incentive for Plasto to share the goal and vision through their participation in the project. Plasto has need for higher value tools, and tool manufacturers wish to supply higher value tools.

The IC2 project's main goal was to strengthen competitiveness of European tool manufacturers through work packages with different technological development focus. Because it was a EU project, the actors who participated worked towards the shared goal, but this does not necessarily mean that they internalised it. Plasto entered the project with a problem they wanted to solve, but does reaching this goal effect the overall goal of the project? For the research institutions involved the value from the project is regarded differently. Whereas Plasto measured project success in terms of increased earnings on improved tools, the research partners valued the fact that they contributed to the industry.

Tool manufacturers wished to make better moulds adding value to their products. The different views on value in this project correlates well with each other because they all reach for the same overall goal of the project.

The IC2 project was however not aimed at creating shared value beyond financial sustainability.

Shared measurement system – measuring the output

The project gave no indication that there was a shared measurement systems in place other than reaching the main objectives of the different work packages. The variety of organizations points to there being independent measuring practices for each actor, like Plasto who focus on the knowledge they gained and the cost reduction from the project. The reason for there not being more specific measuring points than enhancing competitiveness of European tools suppliers might be due to the exploratory character of the project, and setting strict measuring requirements would restrict innovativeness.

Mutually reinforcing activities – coordinating resources

Plasto's goal was to solve their problem with air traps in their tools. To do this the tool's quality had to be enhanced. The diversity of actors who participated in the project must have ensured that they did have different goals, but also different resources they can contribute with. Mutually reinforcing activities can be interpreted as coordinating resources doing transaction activities. The resources Plasto contributed with were transformed through transaction activities together with actors in the project. It can be said that they are mutually reinforcing because each actor is contributing with different resources. In Plasto's case, this is development with respect to tools, while other actors contributed with knowledge about AM. The different work packages consisted of more aspects of tool manufacturing, including surface treatment and installation of sensor to monitor the tools during production. As different actors with different specialities contributed through different activities it can be concluded that they engaged in mutually reinforcing activities.

Constant communication – Coordinating resources

IC2 shows various levels of communication through different channels. The project issued project reports at given intervals during the project that informed participants about status on the work packages. The frequent communication between Plasto and actors who participated in the solution is representative for the aspect of communication in ESVC. There is great trust between Plasto and the research partner SRM as they have worked together before and after the project. Communication is important here because Plasto worked tightly with suppliers of a valuable resource, namely knowledge. Since a lot of their products are resource intensive in terms of knowledge, and this is gained in quality tools, a secure relationship to these actors are important to Plasto. That is, a relationship where Plasto can exploit the knowledge of the suppliers, but without running the risk of being dependant on a few.

Backbone support

The European commission were the actor who mobilized the most financial resources by far. Considering that EC doesn’t have economic interest in the outcome of the project, they can be regarded as an independent actor. Thus, the representative from EC is defined as a backbone support, responsible for keeping track of progress and the fulfilment of milestones throughout the project i.e. guiding the vision.

Table 6.4 The elements of ESVC compared with activities in the IC2 project

ESVC	***Activity***
Shared vision	Goals of the project
Shared measurement	
Reinforcing activities	Difference in actor dimensions
Communication	Case discussion Newsletters Seminars
Backbone supports	Project officer from EC

7 Discussion

The following chapter discusses the findings in the analysis and its implications for the research questions.

7.1 Clarifying and overcoming the barriers of AM implementation

The expectations for the research were that the results would indicate that implementing AM poses a variety of barriers and that a company would overcome these barriers through interactions. The discussion below shows some of the barriers that were identified, and how these barriers were overcome by interacting with actors in the network.

7.1.1 Strategic fit and application

Initially this thesis focused on the need for innovative capabilities to implement AM in that an organization would need to acquire novel knowledge related to the process of AM. It was assumed that the various steps in the process required different disciplines of skills to be adapted requiring the organization to have dynamic capabilities. The findings show that the process model in Figure 4.1 is partially relevant, but important barriers are also found outside the actual process of AM.

The first barrier may be that AM is not fit in every context. The case company portrayed a competitive position that may benefit from AM in their operations. Identifying the need for, or the possibility for AM implementation is a barrier that are discussed below in relations to knowledge about AM.

7.1.2 Knowledge about application

The first barrier to be identified is the lack of knowledge about the application of AM, indicating there are barriers not only in relation to the technical aspects of AM. This was demonstrated by additive manufacturing being introduced by a research partner as a solution to the air traps, whereas the case company had the idea of implementing cooling channels without a viable method of doing so. Application knowledge of AM was new to the case company, which suggests that in certain cases the opportunities provided by AM are unknown. The reason for the lack of this knowledge might be due to the novelty of the technology and that the full range of benefits it can provide are illusive. In addition, since AM is a rather new concept the technology is evolving and changing, exposing new benefits and limitations, making it difficult to keep an updated knowledge pool. The findings in the case shows how interactions were used to overcome this barrier by combining the resources of the case company with the resources of network partners through discussion groups, and ultimately develop knowledge about application.

Using AM effectively is mentioned in the introduction of the thesis and is relevant for the barrier of application knowledge. The importance comes from the fact that AM is a technology that can be beneficial in some aspects of production, but is directly ineffective in other aspect. Literature identified in which areas AM is beneficial to an organization, and concluded that the case company's competitive profile would benefit from AM. In relation to application this is important because trying to implement AM on the wrong premise may offset the benefits one tries to acquire. In such a scenario, barriers of a technical nature can emerge and some were identified in the analysis of the case company. The most notable limitations that were identified are size, cost and quality.

7.1.3 Size limitations

Findings show that the case company does not use the technology in current production. This sheds light on another barrier pertaining to AM, namely size limitations. The case company is currently involved in a project where they manufacture large parts, which AM technology does not support. This is due to the size limitation inherent in the machines. In addition, IC2 did not focus their solution on creating large parts. However, we found that the case company are thinking of the possibility of using AM as a support technology in creating large parts and/or produce for variety through modulization. However, this is not currently relevant for the case company due to quality requirements in IM that AM does not provide. There is an emphasis on the word thinking here, because there isn't an explicit plan to implement this. It's reasonable to believe that, in the event of this becoming reality, it would happen through a research project incorporating network partners. The reason for this is that a project to utilize AM for this purpose are likely to require considerable investment, thus imposing risk. Cost is proven through the literature and the case analysis, to be a major implication and barrier to implementing AM. Both in respect to investment in AM technology and investment in research and development. These costs also carry an elevated risk because AM's benefits and limitations are complex resulting in an uncertain outcome. This suggests that the need for financial support is important for the case company, and can be achieved by sharing investment risk with partners, or get public funding through research projects. IC2 exemplified how the risk can be disseminated by sharing cost and use public funding. In addition to cost, creating larger parts would have other implications than those identified in IC2, such as strength or quality requirements of parts. Hence, it would be beneficial to engage in resource coordination to develop knowledge about how and where AM can add value in the production of larger parts. This may be related to the choice of material or if modulization is the most effective use.

7.1.4 Opposition

The interviews indicated that there was an inherent opposition towards AM in the case company. This was due to a lack of knowledge, the premonition that AM would outcompete IM by 2024 and the notion that layered manufacturing technology doesn't deliver the right quality. This mental barrier differs from the more technical barriers, but is equally important, because it inhibits innovation, and can in certain cases close off vital information channels in the network. Opposition towards AM were not part of the initial expectations of this thesis, but emerged in the analysis of the case. It is important to note, that the opposition towards AM can be considered a soft opposition or healthy scepticism, as the case company are engaged in 3D-printing technology through rapid prototyping and have considered AM technology as intriguing. The findings show that the case company's scepticism was reduces after the IC2 project due to the realization that AM has a larger potential than they previously believed. Their participation also revealed that the scepticism was well placed because in addition to learning about the possibilities of AM, they learned that AM requires more knowledge than previously thought, which is in line with the initial expectations.

7.1.5 Explicit knowledge variety

The research question expected AM to pose challenges in implementation, especially in relation to knowledge. Findings in the analysis have shown that various knowledge is required to utilize AM in operations. The initial guide to knowledge that is needed was the AM process described in the theory chapter. The analysis showed that there were correlating tendencies between the case and these process steps, namely, parts design, programming and skills in different manufacturing technologies. Here, we see how cost is incurred in the development stage because there is need for skilled workers in different disciplines. The case company stated that they were surprised at the level of knowledge that was needed to use AM, such as knowledge about materials and the building process.

The need for a variety of knowledge is demonstrated by the case company not having knowledge about AM, but still participated heavily in the solution that utilized AM. More noteworthy is that the technical part of the solution, with the exception of AM, was largely performed by the case company in cooperation with research partners. AM enabled the solution by being combined with knowledge the case company possess in tool design and tool application. Knowledge about tools is not a prerequisite for using AM in general, but it shows how AM can be combined with different resources and knowledge to create value.

IC2 demonstrated a variety of actors who participated, and a notable mention is the contribution of CNC-machining in making the mould. This posed different challenges to using AM, first, one needs knowledge of this manufacturing method (CNC), second these methods needed to be combined, which demands skills in computer programming. The characteristics of the finished tool were such that the combination of the manufacturing technologies required an intricate knowledge about both, because they were supposed to follow each other seamlessly. Additionally, the appropriate material would have to be chosen, which requires knowledge of materials regarding what's available for AM and if the chosen material is compatible with required specifications. For example, the seam between the technologies would need to tolerate the forces in injection moulding.

The variety of knowledge needed to use AM strongly indicates that interaction is important when implementing AM. The range of required knowledge points to the conclusion that the arguments for technological development can be applied in implementing AM. Especially with respect to resource coordination because it seems unlikely that a company can possess all the knowledge necessary to achieve an effective implementation. This leads to knowledge development as was demonstrated in the analysis. Here, the case company expanded their knowledge about application of the technology and the AM process relating to their products. The findings in the analysis also showed that to use AM, an organization should mobilize resources to use the solution efficiently in their process. However, since AM hasn't been used in later products this could indicate that the case company could have mobilized more resources to expand areas of application, or that limitations in AM reduces the number of possible applications.

7.1.6 Interactions

The arguments for technological development were identifiable in the case, and especially in the IC2 project. The barriers presented in the case were largely overcome using interactions by the definition used in this thesis.

The expectation that AM needs interactions to be implemented effectively and used efficiently is identifiable in the analysis of the case. The case company may not have known of the potential of AM to fix their problem if it weren't for the coordination of resources that lead to the solution. AM was not part of the initial goal for the case company, but rather introduced by a research partner. In addition, the amount of knowledge needed in different disciplines indicate that interactions are beneficial to get the full effect of AM e.g. more complex uses than RP.

One interesting aspect that was found in the analysis is that the case company keeps a strong tie to SRM through their development manager. Consequently, information and knowledge are available to the case company from actors whom they don't have a formal relationship with. Networks have the characteristic of being in an evolving state and the interdependencies discussed earlier in the thesis is applicable to the notion that interactions are important to use AM. Now, the suppliers of tools have expanded knowledge of using AM, which influence the network, in that the tool manufacturers become more competitive. Even though the case company doesn't have any products currently relying on AM, they have access to the technology through their network. Since they participated in developing the solution it is reasonable to believe they have a stronger relationship with actors who can facilitate further use of AM, thus demonstrating how interactions are beneficial by giving the case company access to the technology without having to invest in their own AM technology. Through their partners in the network they have overcome the barrier of costly machinery and are able to use the technology on products that are fit for it e.g. tools.

In IC2 the barrier was not implementing AM, but AM was the solution to the barriers presented by traditional manufacturing technology. One of the more interesting findings in the research is that AM have possibilities to enhance products and processes as a supporting technology. The scepticism the case company had towards AM has been put to rest with this notion, although we also found AM is a resource intensive technology. Although the findings point to AM being resource intensive in the initial stages in areas such as research and development, the findings indicate that after implementation, this barrier ceases to be relevant. This indicates that it could be beneficial to implement AM in various activities, improving the skills related to the technology to internalize the skills and competencies needed to use it efficiently. In addition, using AM more often may create an environment for technological development, giving an organization more knowledge about the technology, thus providing better foundation for developing new knowledge through resource coordination and resource mobilization in the future.

7.2 Additive manufacturing's effect on Shared value

The following section discuss findings in the analysis considering SVC. Literature indicated that AM can support SVC and this discussion aims at substantiating those findings. Most prominent are the findings that are connected to redefining productivity in the value chain, which are listed in Table 7.1.

Reconceive P/M – AM's potential to reconceive products and markets are identified in rapid prototyping and AM's ability to create small internal structures. The use of AM technology to create prototypes is valuable to the case company because prototyping with 3D-printing have the effect of enabling employees to visualize products and can result in better product design. Furthermore, this may result in a larger potential to reconceive products in cooperation with customers due to visualization. AMs ability to create small structures are supportive of the activity of reconceiving markets and products. The findings point to this because the novel method exposes new possibilities for changing products for the better, like the upgrade witnessed in IC2.

Profits - The outcome of IC2 added value to the moulds, thus adding value to the case company's end-product. In a SVC perspective, this is the first aspect that needs to be in place because without it there would be no reason to implement the solution. We'll see that the benefits that provided the added value are also the benefits that creates shared value. The main driver of SVC that are identified is based on the finding that higher quality tools are more profitable for the case company.

Procurement – IC2 raised the competitiveness of European tool manufacturers and enabled Plasto to raise the profits on the tools they used. Since Plasto are focusing on buying tools from China to reduce costs, improvement on the profitability of tools purchased from European suppliers can enable Plasto to purchase tools from suppliers in closer proximity. Consequentially, there are a variety of SVC effects that can benefit Plasto. First, closer relationships are easier to maintain and are important in a situation where Plasto needs innovative solutions for their tools. Findings in the case show that Plasto are relying on their innovativity in tool making to deliver products, thus having access to suppliers in close proximity can raise their competitiveness. It is important that the solution can be adapted to other tools as well for this to be relevant. We have already seen that the solution from IC2 is not adaptable to Plasto's larger products and if this indicates a lack in adaptability for the solution in general, the SVC effect will be less relevant.

Energy and logistics – Higher quality tools with an increased profitability is illustrative of how SVC effects are interdependent. Being able to procure tools in closer proximity will influence logistics and transportation. Since the proximity to suppliers are shorter, the distances the tools need to travel are shorter and this directly affect SVC by reducing fuel consumption, and thus energy use. However, this does not consider the energy use of AM technology. Since AM uses more energy than other methods of manufacturing, the energy savings may not be as large as indicated.

Resource use – Increased quality on the tools increases their lifetime, reducing the need to purchase additional tools. Reducing the number of tools being purchased will have a positive effect on profitability and on resource use since fewer resources are used in production of tools. These effects require that the correct conditions of cost per tool is competitive with those from China. Another aspect of SVC emerges from this, because the localisation aspect of value chain productivity claims that transaction cost offsets lower cost products. Hence, in a SVC perspective there might be more to gain from purchasing tools from more localised suppliers than Chinese suppliers even if the purchasing costs are higher.

Although the results indicate that AM can enable SVC, it is important to consider the limitations of the technology. The raw material used in AM may have an environmental impact that is larger compared to other methods. In addition, since AM make proximations of the modelled part, there may be issues related to quality, which can impact productivity negatively in industries with high quality requirements. Findings in the case indicates that AM can support SVC in various aspects, but it does not show that this can be generalised in every situation. This discussion points to benefits largely connected to logistics and supplier relations. However, the complexity of these issues may obscure aspects of AM that can offset the contribution to SVC e.g. the cost of AM technology and resources required in development.

Table 7.1 SVC aspects in redefining productivity in the value chain. that are identified in the case

SVC aspect	***Description***
Procurement	Easier to maintain closer relationship and gain innovative effects through more intensive interfaces.
Energy and logistics	Shorter shipping distance from Europe than from China
Resources use	Improved tool lifetime reduces resource use
Localisation	Transaction cost

7.2.1.1 *Sustainability and SVC in IC2 (interactions supporting SVC)*

The research questions are outlined so that it would seem interactions are important for SVC, or at least an important supporting process. It was earlier argued that SVC demands innovative capabilities to create novel solutions to future challenges relating to environment, social issues and profit. Interactions are the foundation for technological development in the arguments of this thesis, thus indicating that shared value is created through interactions. The arguments of technological development coincide with the elements of ESVC to some degree, making it possible to determine if IC2 is a project that creates shared value, or have the potential to create shared value.

IC2 lacks objectives with environmental and social connotations, which does not favour the project as a shared value candidate. However, shared value is complex, and as discussed, there are different paths to creating shared value, and an organization is not eligible for all the measures of achieving SVC. IC2 was aimed at boosting the competitiveness of European tool manufacturers, resulting in enhanced economic sustainability of these suppliers, which is a steppingstone to create shared value. Additionally, the interactions actors engaged in can be viewed as a measure to enable local cluster development. "Local" is a diffuse term because in context of IC2 it means in Europe, but nonetheless the project can be said to have strengthened the local cluster. According to IC2, it strengthened competitiveness of tool suppliers, which will boost knowledge and access to valuable resources for other actors connected to this cluster. Plasto is one of these actors, who have gained access to innovative technology through the project. In addition, the analysis showed that other actors also gained value in different measures, such as research institutions who can point to successfully contributing to the industry.

IC2 facilitated technological development that required heavy investing. Through the project, actors who participated were relieved of financial risk connected to developing the solution, which was necessary for the case company to implement AM. Avenues of SVC can be financially demanding, and the ESVC framework mention this as one of the main barriers to creating shared value. Thus, IC2, through confronting this barrier have affiliation with ESVC. On the other hand, another barrier that is mentioned is prevention of free riders, and the knowledge suppliers have acquired may be taken advantage of by other actors who didn't participate in IC2. However, by reducing risk through public support this barrier may not be as relevant to the actors in the project. In addition, those who participated may have gained other benefits such as tacit knowledge, that outsiders will not have access to.

The analysis and discussion has shown that IC2 had some similarities with ESVC. Due to these similarities and the shared value that were created through the project, there are indications that in addition to supporting the implementation of AM, interactions also have a direct link to creating shared value. Figure 7.1 illustrates how the initial figure that explained how the topics are connected, should be revised, and emphasises that there is a significant connection between interactions and shared value.

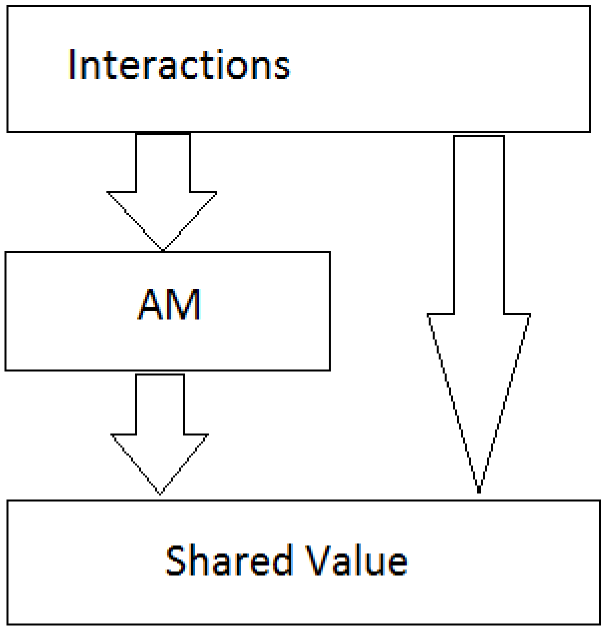

Figure 7.1 Revised model of the topic's interconnectedness

7.3 Indication of AM's effect on SVC and competitiveness

The main goal of this study is to explore the possibilities AM present to create shared value with the aim of becoming more competitive. The results showed that by implementing AM, the case company could create higher quality tools that lead to higher earnings. In addition, the analysis indicated that the improved tools could have a positive impact on shared value creation, especially pertaining to the avenue of redefining productivity in the value chain. Furthermore, as discussed in the literature, the avenues of SVC are interconnected, which suggests that AM may have a larger impact than identified here. However, it's difficult to see how AM could have a direct effect on enabling local cluster development beyond being beneficial for isolated actors. The strongest indication of enabling local clusters in the thesis are the activities performed to enable technological development through interactions.

The analysis shows that AM's contribution to the finished product is "small" compared to the total process from raw material to the case company's finished product. However, AM helped create value through the characteristics the technology offers. This indicates that AM may be beneficial as a supporting technology, which is also evident from the use of AM technology in supporting product design and sales. The contribution made to SVC, are in this case through reconceiving products by exploiting AM's unique method of manufacturing.

Based on these points, it's not possible to conclude that AM can create shared value by itself. Instead, it may indicate that interactions are the main driver behind SVC, and that AM can prove beneficial to this end in certain situations. However, this would demand investment in implementing the technology, and in relationships to access necessary resources to be successful. Consequently, AM can contribute to SVC, and thus competitiveness, but it cannot make a business more competitive without sufficient support e.g. other technologies, human resources, relationships.

8 Conclusion and further research

The goal of the research was to examine how AM can successfully be implemented in a company and support the creation of shared value. Implementation of AM poses different barriers such as cost and knowledge requirements, but also opportunities through the unique characteristic of layered manufacturing technology. It's these characteristics, illustrated through for example easier customization and rapid ramp-up of manufacturing capability that indicates possibilities to create shared value. This study hypothesised that interactions would be essential to successfully utilize AM technology by overcoming the barriers through coordinating resources with network actors. To test the hypotheses the case company Plasto was approach based on their previous experience with AM. The findings from this case uncovered barriers that were hypothesised at the beginning of the thesis as well as some barriers that were unravelled by the analysis.

A framework was derived from literature in order to analyse the case, and was primarily based on Håkansson's (1987) Technological development: a network approach, Porter & Kramer's (2011) Creating Shared Value and various literature regarding AM. The framework was outlined as an imagined guide to implementing AM, considering its implications on an organization's value chain. The conceptual framework provided a good basis for discussing the research questions and investigate the hypotheses in a structured manner. It was structured in a way that made sure important themes were covered, while connecting the main topics of the thesis. Furthermore, it allowed an analysis that assessed the case on the product level, the organizational level and the network level.

8.1 Need for knowledge

Findings in the analysis pointed towards knowledge being the most crucial factor in implementing AM. The process of AM illustrated this point in revealing that each step required knowledge that have indirect connections to AM, such as programming and knowledge about tools. In addition, findings indicated that AM may have a variety of uses in an organization, but these are not obvious due to lack of knowledge about the technology. Barriers that were identified in the case provides possibilities to discover more applications e.g. the barrier of size limitation. Finding a solution for using AM for larger products will probably have a variety of approaches. This research has mentioned modulization, but there could be other solutions such as manufacturing entire parts with layered manufacturing technology, or scaling up the solution in the IC2 case, depending on the specifications of the product.

Cost were mentioned as a barrier due to several factors, including high raw material cost, high machine cost and high energy use in the process. However, these costs were debunked by the case company to some degree, in that the development were costly, but the tool had the same cost as tools produced with traditional methods, while improving the profitability of the end-product.

8.1.1 Interactions

The need for different knowledge points to the benefit of interactions. However, it can't be proven that interactions are a prerequisite to implement AM, although it's strongly indicated based on the notion that an organization can't possess all the necessary skills themselves. Especially since other applications than the one portrayed here would require knowledge about the certain situation e.g. using AM for manufacturing parts for air planes would require knowledge about the aerospace industry. In addition, the findings suggest that interactions are important in discovering new opportunities for applying AM through the argument of knowledge development.

Thus, hypothesis 1 is partly confirmed in that there are need for different skills and capabilities in an organization to utilize AM, and that interactions is a favourable course of action to gain access to needed resources. However, the hypothesis claims that interactions are necessary, which this research is unable to prove in general. An example of this is how the case company uses AM for rapid prototyping purposes, which does not necessitate complex interactions to implement.

8.2 AM provide SVC in practice

The second hypothesis is based on previous research, which indicates that AM can create shared value. This thesis showed that AM can create shared value in different avenues of the SVC framework in practice, most notably in redefining productivity in the value chain. Something of consideration is that IC2 did not portray any common goals pertaining to SVC e.g. environment or social issues, which may indicate that the potential for creating shared value with AM may be higher than demonstrated here. On the other hand, the discussion argued that AM is not an enabler of SVC, but merely support certain aspects of it. Furthermore, the contribution of AM to the finished product raise a question about the viability of AM as an enabler of SVC considering the resources needed to implement it.

Essentially, if the SVC contribution is large enough to justify the investment. Additionally, it was stressed that AM would have to be used correctly to achieve SVC goals. However, further research is needed to determine to what degree AM can directly enable SVC.

The overarching aim of the research was to find if the implementation of AM can provide competitive advantage. The discussion showed that it is difficult to assess whether competitiveness comes as a direct result of using AM or not, but the technology may provide support for the competitive strategy in the case company. However, implementing AM poses barriers, where the most notable one is that it requires a variety of knowledge to be effectively utilized. Barriers were overcome by the case company's ability to combine their resources with other actors in their network, creating a solution that included knowledge from different fields. Thus, proving the essential role played by interactions in implementing AM for the case company. Furthermore, the discussion suggests that interactions have a larger connection to SVC than was the initial focus. Since there was a lack of focus on SVC in the project there may be a larger potential for SVC by incorporating goals pertaining to environment and social issues, which may reveal novel applications for AM that creates shared value.

Hypothesis 2 is confirmed through this research in the context of the case company. Based on the notion that SVC builds competitiveness, there is also an indication that using AM with aim to create shared value can enhance an organization's competitiveness. However, the results indicate that the success of such projects, are connected to the organizations capability to utilize their network, and the willingness to focus on SVC.

8.3 Recommendations for future research

The findings in this research suggest that implementing AM in a different environment than the one portrayed here, would present different possibilities for application. This could possibly reveal different barriers, and other prospects for the avenues of SVC. The conceptual framework may support further research by considering AM's benefits and limitations in relation to an organization's value chain, which can be combined with SVC considerations. Furthermore, the limitations listed here may not be as relevant in the future as the technology evolves, which may increase the possible applications in various industries. Thus, the framework may need further expansion, which can enable a larger focus on applications that are specifically aimed at SVC.

The research has focused on using the network to implement AM through resource coordination and joint knowledge development. It could have been beneficial to review implementation of AM in the perspective of dynamic capabilities as the technology is rapidly evolving and may prove useful in an increasing number of cases. The dynamic capabilities view would address issues about how an organization need to adapt their capabilities to utilize AM, which includes supporting processes such as product development. A study in this perspective could also be based on and expand the framework used to analyse the case company in this thesis.

8.4 Recommendation for managers/practitioners

The importance of this research is found in the realization that AM can provide benefits on various levels in an organization. Being aware of AM as a technology with a completely different set of possibilities for an organization's value chain activities should be a focus for businesses. However, the notion of the benefits AM is providing should be approached with caution due to the resources that are needed to utilize AM. In addition, businesses should be aware of the limitations inherent in AM technology, and especially that the technology is demanding in the implementation phase. The case company described it well by saying that AM is not a "Plug & Play" technology, but demanding in knowledge and resources. The main point is that businesses should be open minded and aware of this technology as it has proven to provide benefits in certain situations. To this end, business may benefit from the conceptual framework to assess their own value chain in relation to AM's possibilities and barriers.

8.5 Limitations

The case study would be more comprehensive if more actors who were involved in the development process were interviewed to get a clearer view of what benefits interactions contributed with. In addition, other actors could have illuminated more barriers to the implementation of AM as experienced with a different foundation of knowledge. It would also be interesting to assess SVC contribution of AM in an environment where SVC was aggressively sought after.

9 References

Achillas, C., Aidonis, D., Iakovou, E., Thymianidis, M., & Tzetzis, D. (2015). A methodological framework for the inclusion of modern additive manufacturing into the production portfolio of a focused factory. *Journal of Manufacturing Systems*, *37, Part 1*, 328–339. https://doi.org/10.1016/j.jmsy.2014.07.014

Andersen, P. H., Cook, N., & Marceau, J. (2004). Dynamic innovation strategies and stable networks in the construction industry: Implanting solar energy projects in the Sydney Olympic Village. *Journal of Business Research*, *57*(4), 351–360. https://doi.org/10.1016/S0148-2963(02)00391-0

Araujo, L., Dubois, A., & Gadde, L.-E. (1999). Managing Interfaces with Suppliers. *Industrial Marketing Management*, *28*(5), 497–506. https://doi.org/10.1016/S0019-8501(99)00077-2

Barnes, D. (2001). *Understanding Business: Processes*. Psychology Press.

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, *28*(1), 31–56. https://doi.org/10.1191/0309132504ph469oa

Berman, B. (2013). 3D printing: the new industrial revolution. *IEEE Engineering Management Review*, *41*(4), 72–80. https://doi.org/10.1109/EMR.2013.6693869

Bessant, J. (1994). Towards total integrated manufacturing. *International Journal of Production Economics*, *34*(3), 237–251. https://doi.org/10.1016/0925-5273(94)90155-4

Blankenburg, D., & Johanson, J. (1992). Managing network connections in international business. *Scandinavian International Business Review*, *1*(1), 5–19. https://doi.org/10.1016/0962-9262(92)90033-3

BRANDSTORY: 3D-printing revolusjonerer industrien. (2015, October 27). Retrieved October 31, 2016, from http://www.tu.no/brandstory/siemens/brandstory-3d-printing-revolusjonerer-industrien/275896

Bryman, A. (2012). *Social Research Methods*. OUP Oxford.

Chia, H. N., & Wu, B. M. (2015). Recent advances in 3D printing of biomaterials. *Journal of Biological Engineering*, *9*, 4. https://doi.org/10.1186/s13036-015-0001-4

Choi, T. Y., Dooley, K. J., & Rungtusanatham, M. (2001). Supply networks and complex adaptive systems: control versus emergence. *Journal of Operations Management*, *19*(3), 351–366. https://doi.org/10.1016/S0272-6963(00)00068-1

Christopher, M. (2011). *Logistics and Supply Chain Management* (4 edition). Harlow, England; New York: FT Press.

Conner, B. P., Manogharan, G. P., Martof, A. N., Rodomsky, L. M., Rodomsky, C. M., Jordan, D. C., & Limperos, J. W. (2014). Making sense of 3-D printing: Creating a map of additive manufacturing products and services. *Additive Manufacturing*, *1–4*, 64–76. https://doi.org/10.1016/j.addma.2014.08.005

Cousins, P. D., & Spekman, R. (2003). Strategic supply and the management of inter- and intra-organisational relationships. *Journal of Purchasing and Supply Management*, *9*(1), 19–29. https://doi.org/10.1016/S1478-4092(02)00036-5

Cousins, P., Lamming, R., Lawson, B., & Squire, B. (2007). *Strategic Supply Management: Principles, theories and practice* (1 edition). Harlow, England ; New York: Prentice Hall.

Cousins, P., Lamming, R., Lawson, B., & Squire, B. (2008). *Strategic Supply Management: Principles, Theories and Practice*. Pearson Education.

Craig R. Carter, & Dale S. Rogers. (2008). A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical*

Distribution & Logistics Management, *38*(5), 360–387. https://doi.org/10.1108/09600030810882816

Daniel R Eyers, & Andrew T Potter. (2015). E-commerce channels for additive manufacturing: an exploratory study. *Journal of Manufacturing Technology Management*, *26*(3), 390–411. https://doi.org/10.1108/JMTM-08-2013-0102

Dicken, P. (2011). *Global Shift, Sixth Edition: Mapping the Changing Contours of the World Economy* (6 edition). London: SAGE Publications Ltd.

Douglas S, T., & Stanley W, G. (2014). *Costs and Cost Effectiveness of Additive Manufacturing* (Literature Review and Discussion No. 1176). National Institute of Standards and Technology.

Dubois, A., & Gadde, L.-E. (2002). Systematic combining: an abductive approach to case research. *Journal of Business Research*, *55*(7), 553–560. https://doi.org/10.1016/S0148-2963(00)00195-8

Dyer, J. H. (1996). Specialized Supplier Networks as a Source of Competitive Advantage: Evidence from the Auto Industry. *Strategic Management Journal*, *17*(4), 271–291.

Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: the Toyota case. *Strategic Management Journal*, *21*(3), 345–367. https://doi.org/10.1002/(SICI)1097-0266(200003)21:3<345::AID-SMJ96>3.0.CO;2-N

F. Ian Stuart, & David McCutcheon. (1996). Sustaining strategic supplier alliances: Profiling the dynamic requirements for continued development. *International Journal of Operations & Production Management*, *16*(10), 5–22. https://doi.org/10.1108/01443579610130664

Fet, A. M., & Jenssen, M. M. (2014). *SISVI Industri og forskningsseminar: Shared Value Creation and the international firm* (Seminar summary). NTNU.

Fuges, C. M. (2016, September 12). Reducing Disposal Cost for Separator Vacuums: Additive Manufacturing. Retrieved April 25, 2017, from http://www.additivemanufacturing.media/blog/post/seriously-safety-first

Gadde, L.-E., Huemer, L., & Håkansson, H. (2003). Strategizing in industrial networks. *Industrial Marketing Management*, *32*(5), 357–364. https://doi.org/10.1016/S0019-8501(03)00009-9

Gadde, L.-E., & Snehota, I. (2000). Making the Most of Supplier Relationships. *Industrial Marketing Management*, *29*(4), 305–316. https://doi.org/10.1016/S0019-8501(00)00109-7

Gebler, M., Schoot Uiterkamp, A. J. M., & Visser, C. (2014). A global sustainability perspective on 3D printing technologies. *Energy Policy*, *74*, 158–167. https://doi.org/10.1016/j.enpol.2014.08.033

Gibson, I. (2010). *Additive manufacturing technologies : rapid prototyping to direct digital manufacturing*. Springer.

Gibson, I., Rosen, D., & Stucker, B. (2015). *Additive Manufacturing Technologies*. New York, NY: Springer New York. Retrieved from http://link.springer.com/10.1007/978-1-4939-2113-3

Granovetter, M. S. (1973). The Strength of Weak Ties. *American Journal of Sociology*, *78*(6), 1360–1380.

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic Management Journal*, *21*(3), 203–215. https://doi.org/10.1002/(SICI)1097-0266(200003)21:3<203::AID-SMJ102>3.0.CO;2-K

Håkansson, H. (1987). *Industrial technological development: a network approach*. Croom Helm.

Håkansson, H., & Snehota, I. (1995). Relationships in business. In *Developing relationships in business networks* (pp. 1–23). London: Routledge.

Handfield, R. B., Ragatz, G. L., Petersen, K. J., & Monczka, R. M. (1999). Involving Suppliers in New Product Development. *California Management Review*, *42*(1), 59–82.

Handfield, R., Sroufe, R., & Walton, S. (2005). Integrating environmental management and supply chain strategies. *Business Strategy and the Environment*, *14*(1), 1–19. https://doi.org/10.1002/bse.422

Harland, C., Zheng, J., Johnsen, T., & Lamming, R. (2004). A Conceptual Model for Researching the Creation and Operation of Supply Networks1. *British Journal of Management*, *15*(1), 1–21. https://doi.org/10.1111/j.1467-8551.2004.t01-1-00397.x

Heiko A. von der Gracht, & Inga-Lena Darkow. (2016). Energy-constrained and low-carbon scenarios for the transportation and logistics industry. *The International Journal of Logistics Management*, *27*(1), 142–166. https://doi.org/10.1108/IJLM-12-2013-0150

Home - IC2. (n.d.). Retrieved May 28, 2017, from http://www.ic2-eu.org/

Huang, S. H., Liu, P., Mokasdar, A., & Hou, L. (2012). Additive manufacturing and its societal impact: a literature review. *The International Journal of Advanced Manufacturing Technology*, *67*(5–8), 1191–1203. https://doi.org/10.1007/s00170-012-4558-5

Igarashi, M., de Boer, L., & Fet, A. M. (2013). What is required for greener supplier selection? A literature review and conceptual model development. *Journal of Purchasing and Supply Management*, *19*(4), 247–263. https://doi.org/10.1016/j.pursup.2013.06.001

ISO/ASTM 52900:2015(E). (2015, December). *Standard terminology for Additive Manufacturing*. ISO-standard. Retrieved from http://www.astm.org/FULL_TEXT/F2792/HTML/F2792.htm

Jan Holmström, & Jouni Partanen. (2014). Digital manufacturing-driven transformations of service supply chains for complex products. *Supply Chain Management: An International Journal*, *19*(4), 421–430. https://doi.org/10.1108/SCM-10-2013-0387

Jan Holmström, Jouni Partanen, Jukka Tuomi, & Manfred Walter. (2010). Rapid manufacturing in the spare parts supply chain: Alternative approaches to capacity deployment. *Journal of Manufacturing Technology Management*, *21*(6), 687–697. https://doi.org/10.1108/17410381011063996

Kramer, M. R., & Pfitzer, M. W. (2016, October 1). The Ecosystem of Shared Value. Retrieved February 10, 2017, from https://hbr.org/2016/10/the-ecosystem-of-shared-value

Laroche, M., Bergeron, J., & Barbaro-Forleo, G. (2001). Targeting consumers who are willing to pay more for environmentally friendly products. *Journal of Consumer Marketing*, *18*(6), 503–520. https://doi.org/10.1108/EUM0000000006155

Luis Araujo, Lars-Erik Gadde, & Anna Dubois. (2016). Purchasing and supply management and the role of supplier interfaces. *IMP Journal*, *10*(1), 2–24. https://doi.org/10.1108/IMP-06-2015-0025

Mellor, S., Hao, L., & Zhang, D. (2014). Additive manufacturing: A framework for implementation. *International Journal of Production Economics*, *149*, 194–201. https://doi.org/10.1016/j.ijpe.2013.07.008

Meyer, R., & Wit, B. de. (2014). *Strategy: An International Perspective* (5 edition). Andover: Cengage Learning EMEA.

Michalski MH, & Ross JS. (2014). The shape of things to come: 3d printing in medicine. *JAMA*, *312*(21), 2213–2214. https://doi.org/10.1001/jama.2014.9542

Monczka, R. M., Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (1998). Success Factors in Strategic Supplier Alliances: The Buying Company Perspective*. *Decision Sciences*, *29*(3), 553–577. https://doi.org/10.1111/j.1540-5915.1998.tb01354.x

Murphy, P. R., & Poist, R. F. (2002). Socially Responsible Logistics: An Exploratory Study. *Transportation Journal (American Society of Transportation & Logistics Inc)*, *41*(4), 23.

Nærings- og fiskeridepartementet. (2017). *Meld. St. 27 (2016–2017)* (Stortingsmelding) (pp. 9–17). Retrieved from https://www.regjeringen.no/no/dokumenter/meld.-st.-27-20162017/id2546209/

Norsk titanium skal lage titandeler for Boeing. (2016, July 14). Retrieved August 30, 2016, from http://www.tu.no/artikler/norsk-titanium-skal-lage-titandeler-for-boeing/349446

Oversikt over regelverket - regjeringen.no. (2014, November 6). [Government]. Retrieved March 30, 2017, from https://www.regjeringen.no/no/tema/naringsliv/konkurransepolitikk/regler-om-offentlig-stotte-listeside/offentlig-stotte-regelverk/id430118/

Pagell, M., & Wu, Z. (2009). Building a More Complete Theory of Sustainable Supply Chain Management Using Case Studies of 10 Exemplars. *Journal of Supply Chain Management*, *45*(2), 37–56. https://doi.org/10.1111/j.1745-493X.2009.03162.x

Pham, D. T., & Gault, R. S. (1998). A comparison of rapid prototyping technologies. *International Journal of Machine Tools and Manufacture*, *38*(10–11), 1257–1287. https://doi.org/10.1016/S0890-6955(97)00137-5

Piercy, N., & Rich, N. (2015). The relationship between lean operations and sustainable operations. *International Journal of Operations & Production Management*, *35*(2), 282–315. https://doi.org/10.1108/IJOPM-03-2014-0143

Porter, M. E., & Kramer, M. R. (2006, December 1). Strategy and Society: The Link Between Competitive Advantage and Corporate Social Responsibility. Retrieved February 17, 2016, from https://hbr.org/2006/12/strategy-and-society-the-link-between-competitive-advantage-and-corporate-social-responsibility

Porter, M. E., & Kramer, M. R. (2011, January 1). Creating Shared Value. Retrieved February 17, 2016, from https://hbr.org/2011/01/the-big-idea-creating-shared-value

Rogers, D. S., & Tibben-Lembke, R. (2001). An Examination of Reverse Logistics Practices. *Journal of Business Logistics*, *22*(2), 129–148. https://doi.org/10.1002/j.2158-1592.2001.tb00007.x

Sletfjerding, A. B. (2016, March 22). *Additiv tilvirkning: Mulighetene for shared value creation* (Project assignment). NTNU.

Stake, R. E. (2005). Qualitative Case Studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research*, *3rd ed* (pp. 443–466). Thousand Oaks, CA: Sage Publications Ltd.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509–533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Weller, C., Kleer, R., & Piller, F. T. (2015). Economic implications of 3D printing: Market structure models in light of additive manufacturing revisited. *International Journal of Production Economics*, *164*, 43–56. https://doi.org/10.1016/j.ijpe.2015.02.020

A. Appendix Interview guide

Intervju guide

Intro

I introen ønsker jeg å introdusere intervjuobjektet samt introdusere forskningen. Bryman poengterer viktigheten av at starten av intervjuet må inneholde spørsmål som er direkte knyttet til Forskningen. Spørsmål som handler om oppfatning av et tema burde komme før spørsmål som har med kunnskap.

Intervjuobjekt:

- Navn
- Hvilke oppgaver har du i bedriften?
- Stilling
- Hvor lenge har du jobbet der?
- Hva er din utdannelse?

Tanker rundt temaene mine

- Hvilke tanker har du om konseptet SVC?
    - Plastos Produkter
    - Prosjekter som er knyttet til Shared value(Helse)
    - Markeder/produkter
    - Energi og logistikk
    - Ressursbruk
    - Distribusjon
    - Leverandører og kunder
    - Lokasjon
    - Cluster på Åndalsnes
- Hva legger du i begrepet Additive Tilvirkning?
    - Produkter som passer AM kriterier
    - Passer Tools til AM kriteriene?
    - Som kommunikasjon
    - HMS
- Hva legger du i konseptet Interactions, eller samhandling?
    - Hva mener du fra din erfaring, er nytten av dette, eventuelt ulempene?

Hoveddel

I hoveddelen vil jeg se på rammeverket rundt Interactions ved å se på de tre dimensjoner som utgjør et industrielt nettverk. Spørsmålene her knytter seg til Plastos prosjekt med Ekornes.

Plasto

Hvordan vil du karakterisere prosjektet innledningsvis?

- Hva var det opprinnelige målet med prosjektet når dere først møtte Ekornes?
- Hva var produktet som skulle leveres?
- Tidligere kontakt med Ekornes?
- Så dere på dette som et prøveprosjekt?
- Mål med prosjektet i forhold til AM i innledningsfasen?
- I hvilken sammenheng ble AM presentert?
- Var det noen mål som du anser som forenelige med SVC?
- Hvis noen, hvem vil du si var koordinator?
- Var det risiko knyttet til prosjektet? (Før/etter AM introduksjon)
- Tanker om samarbeid tidlig i prosjektet?

Aktører

Her vil jeg vite hvilke aktører som var involvert i prosjektet, med hovedvekt på de som hadde den mest intense «Interface» med Plasto. Jeg vil også ha informasjon om de sekundære aktørene.

Hva legger du i «tett samarbeid»?

- Hvem var med i tett samarbeid?(kontinuerlig og gjensidig informasjonsflyt)
- Hva samarbeidet dere om?
- Design-produkt-form-AM.

AM leverandør

- I hvor stor grad samarbeidet dere med dem?
- Var det flere som leverte AM tjenester?
- Kriterier

Ekornes

- Hvor aktive var Ekornes gjennom prosjektet?

Andre aktører

- Hvilken rolle disse spilte
- Aktører Plasto ville ha med
- Konkurrenter

Ressurser

Først ønsker jeg å vite hvilke ressurser Plasto anser som sine viktigste. Så en konfigurasjon der jeg følger rammeverket om hvilke ressurser Plasto bidrar med i samhandling med andre og internt i innovasjonsprosessen. I tillegg vil jeg vite hvordan konfigurasjonen av ressurser var generelt i nettverket.

Hva er dine tanker om hva som er Plastos mest essensielle ressurser, med spesielt fokus på innovasjon/nye prosjekter?

Hvordan er Plastos ressurskonfigurasjon(Liste)

- Kunnskap(mennesker)
- Fysiske
- Finansielle
- Forhold til andre aktører som kan utnyttes

Hvilke ressurser mobiliserte dere i prosjektet?

- Eksternt
- Internt
- For å skape rapport

Hvem andre var bidragsytere av kunnskap?

- Hvilken kunnskap bidro de forskjellige aktørene med?

Fikk dere tilgang på fysiske eller finansielle ressurser fra andre aktører?

Aktiviteter

Dette omhandler hvilke aktiviteter som ble utført fra Plastos side i prosjektet

Hvordan valgte dere hvem dere skulle samarbeide med?

- AM leverandør
- Komplementære leverandører
- Kriterier?
- Anbefalinger fra andre aktører?
- Tidligere relasjoner

Resurs koordinering:

- Lån av kvalifisert personell?
- Tilgang på fysiske ressurser?
    - Flyttet fysiske ressurser seg?
    - AM teknologi
    - Sprøytestøpingteknologi
- Besøk for å se prosess?

Kunnskapshåndtering

- Har dere rutiner for dette?
- Ble kunnskap absorbert i Plasto?

Informasjonsdeling

- Hvor hyppig er kommunikasjonen?
- Kommunikasjonsform?
- Hvis det var flere aktører som jobbet nærme, ble alle holdt inne i loopen?

Risikohåndtering

- Følte dere at det var risiko knyttet til dette prosjektet?
- Deling av finansielle ressurser?

Transformative aktiviteter

- I hvilken sammenheng kombinerte dere kunnskap for å innovere i dette prosjektet?
- Hvilke ressurser var mest fremtredende i denne kombinasjonen?

Avslutning

Her vil jeg vite hva Plasto tenker de fikk ut av prosjektet. I forhold til målsetning og oppdagelser?

Knowledge Development

- AM
  - Mulige adaptsjoner av AM
  - Lærte dere noe nytt om AM?
  - I forhold til SVC?
  - Barrierer for innføring av AM?
- Formen
  - Positive/negative aspekter på denne?
- Prosess
  - Negative og positive(trade-offs) aspekter
  - Skritt som trengte mer ressurser
  - Nye skritt
- Sluttproduktet dere leverte til Ekornes?
  - Forskjellig hvis dere ikke hadde brukt AM?
- Hvor viktig anser du samhandling for suksess i dette prosjektet?