A business model perspective on additive manufacturing

INGRID PORAT

KLARA HOVSTADIUS
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by

Ingrid Porat
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Ett affärsmodellsperspektiv på additiv tillverkning

av

Ingrid Porat
Klara Hovstadius
Abstract

Additive manufacturing (AM) is an immature manufacturing technology which is often considered to have the potential of disrupting the manufacturing industry and many industrial companies are currently investigating how they can position themselves within the AM market. Technological innovations alone are often insufficient to fully exploit the benefits of new technology and requires to be accompanied with business model innovation. Consequently, companies face challenges to find guidance related to the application of AM; what to offer and to whom (value proposition), how to deliver such offering (value creation) and how to capture the profit (value capture) – that is, how to structure an AM business model. Therefore, this research investigates how large incumbent manufacturing companies tackle the emerging AM market from a business model perspective. The research unpacks the common themes within three business model components (value proposition, value creation and value capture) in the context of an AM business model, where theme 5 is contradicted by theory and by several other themes:

1. Immature demand 
2. Internal cases as a starting point 
3. Knowledge offerings 
4. End-to-end solutions 
5. Broad customer focus 
6. Start in a technology niche, then expand 
7. Invest in machines to learn AM 
8. Change in designer mindset required 
9. Partnerships to drive the AM market forward 
10. A shift in power 
11. Close customer relations 
12. It is a race to the market

The research is based on a multiple-case study consisting of 16 interviews at six different companies and two universities.

Key words: additive manufacturing, business models, Gartner’s hype cycle
Sammanfattning

Additiv tillverkning (AM) är en omogen tillverkningsteknik som anses ha potential att kraftigt påverka den tillverkande industrin och många företag närmar sig nu AM för att undersöka hur de kan ta en stark position på marknaden. Tekologiska innovationer i sig är ofta otillräckliga för att till fullo utnyttja fördelar med ny teknik och därför krävs även innovation av affärsmodeller. Det kan vara svårt för företag att hitta argument och stöd för hur en affärsmodell inom AM ska struktureras, det vill säga avgöra vad som ska erbjudas och till vem (value proposition), hur erbjudandet ska levereras (value creation) och hur vinsten ska tillvaratas (value capture). Därför undersöker den här studien hur stora tillverkande företag möter den växande AM-marknaden utifrån ett affärsmodellsperspektiv. Forskningen påvisar gemensamma teman inom tre affärsmodellskomponenter (value proposition, value creation, value capture) i en AM-kontext, där tema 5 motsägs både av teorin och av flera andra teman:

1. Omogen efterfrågan
2. Starta med interna uppdrag
3. Kunskapserbjudanden
4. Helbetslösningar
5. Brett kundfokus
6. Börja i en tekniknisch, expandera sedan
7. Investera i maskiner för att bygga kunskap
8. Behov av förändring i designers tankesätt
9. Partnerskap för att driva AM-marknaden framåt
10. Maktpositionen skiftar
11. Nära kundrelationer
12. Det pågår ett race till marknaden

Forskningen är baserad på en multipel fallstudie som inkluderar 16 intervjuer på sex olika företag och två universitet.

Nyckelord: additiv tillverkning, affärsmodeller, Gartner’s hype cycle
Acknowledgments

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Ingrid Porat

Klara Hovstadius

Stockholm, June 2018

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## Abbreviations

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<th>Definition</th>
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<tr>
<td>3D</td>
<td>Three-dimensional</td>
</tr>
<tr>
<td>AM</td>
<td>Additive manufacturing</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer-aided design</td>
</tr>
<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>CTO</td>
<td>Chief Technology Officer</td>
</tr>
<tr>
<td>DVD</td>
<td>Digital versatile disc</td>
</tr>
<tr>
<td>IP</td>
<td>Intellectual property</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
<tr>
<td>STL</td>
<td>Surface tessellation format</td>
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## Definitions

<table>
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<th>Term</th>
<th>Definition</th>
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<tr>
<td>Actors</td>
<td>Any actor in the additive manufacturing market</td>
</tr>
<tr>
<td>Companies</td>
<td>Large incumbent manufacturing companies</td>
</tr>
<tr>
<td>Power (in value chain)</td>
<td>The ability to influence the market or other actors</td>
</tr>
<tr>
<td>Process parameters</td>
<td>The right combination of material and machine parameters for a certain component</td>
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Introduction

This chapter introduces the study by covering the background, problem formulation and purpose. Thereafter, the study's delimitations and research contribution are presented.

1.1 Background

In recent years, industrial productivity has dramatically increased due to technological advances. Further, the manufacturing industry has undergone several changes driven by market transformations and technological innovation (Cavalieri et al., 2016), thus transforming the industry into a new digitized generation, often referred to as the fourth industrial revolution or Industry 4.0 (Feld et al., 2014; Heppelmann & Porter, 2014).

The new market landscape has increased the importance of addressing customer needs more intelligently and to capture value through new products and services (Visnjic et al., 2017). This in turn often requires business model innovation (Teece, 2010). One of the emerging technologies, which is powering Industry 4.0 and fulfils these requirements, is additive manufacturing (AM) (Engel et al., 2015). AM refers to “the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies” (ASTM International, 2013). Even though AM has been used in a small scale for over two decades, it has just recently started to be considered as a revolutionary technology, expected to disrupt the manufacturing industry in the coming years. The AM industry is growing rapidly and the global market for AM is predicted to be worth 170 billion SEK in 2025, compared to today’s approximate 16 billion SEK (both for polymeric and metal materials) (Mekpoint, 2016). AM technologies allow making complex and customized products with layer-on-layer techniques instead of using tools or molds. Apart from customized products, AM reduces the need for assembly activities and impacts capital and marginal production costs (Kleer et al., 2015). However, AM also comes with several limitations: the printing is time consuming which makes the throughput speed low, the material does not always match the production processes and there are not yet any common quality standards (Kleer et al., 2015).

As a rule of thumb, industries in which AM adoption is high, or is predicted to be high in the future, are characterized by high value and low volume products. These
are industries where the benefits which AM provides, such as improved product performance, higher customization and shorter time-to-market, outweigh higher production costs. The industries where AM is currently most mature are aerospace and medical/dental. These, together with the automotive industry, are predicted to account for around 50 percent of the AM market by 2020. (Ben-Ner & Siemsen, 2017; Conner et al., 2014; Corman et al., 2017; Bacchetti et al., 2016)

Due to the emergence of AM, organizations are facing pressure to create new business models to capture value from it (Björkdahl et al., 2017). In essence, a business model embodies the organizational and financial architecture of a business by determining the value an organization delivers, how it can organize itself to deliver this value and how to capture part of the value that is delivered (Foss & Saebi, 2017; Teece, 2017). Designing a business model requires creativity, insights and information about customers, competitors and suppliers (Teece, 2010) and the right business model is not often apparent in early stages of emerging industries, such as the AM industry. However, actors who are well positioned and have good business model templates which iteratively can be adjusted, are more likely to succeed (Teece, 2010). Related to this is the concept of business model experimentation, as stated by Sinfield et al. (2012). Business model experimentation is promoting the view of treating the business model as a variable and exploring alternate business models to quickly find new paths for value creation. This to make better decisions about how and where to compete (Sinfield et al., 2012; Chesbrough, 2010).

1.2 Problem formulation

While the potential of AM is considerable and the expectations are high, it also brings several challenges to large incumbent manufacturing companies¹, due to its immaturity compared to traditional manufacturing technologies. One challenge is that academic literature on business effects of AM is limited. Further, most literature to this date tend to focus on the technological aspects of AM, rather than the managerial (Kleer et al., 2015). This in turn leads to a lack of literature which companies can use to find reliable guidance or use to leverage on benchmarking. Thus, investigating the business side of AM and identifying common themes in appropriate business models could work as means for companies to structure their own AM business model and thereby align their activities to develop and deploy AM offerings to the market.

¹ Throughout the report, the large incumbent manufacturing companies will be referred to as “companies”. Other (or any unspecified) organizations in the AM industry will be referred to as “actors”.
1.3 Purpose and research questions

The purpose of this study is to identify how large incumbent manufacturing companies can face the evolvement of the AM market and which the common themes are in how such companies generally reason about AM business models. The research questions formulated to reach the research purpose are:

RQ1: *What are the common themes in proposed AM business models among large incumbent manufacturing companies?*

RQ2: *How are the common themes in the proposed AM business models aligned?*

1.4 Delimitations

This study focuses on some of the largest incumbent manufacturing companies in Sweden, one being the commissioner company. These companies are also among the main actors operating in the Swedish AM market and they all have AM initiatives in place or under development. However, this study does not focus on these companies own current AM business models but on how these companies generally reason about appropriate AM business models. Further, all companies included in the study are either large incumbent manufacturing companies or joint ventures or spin-offs from large incumbent manufacturing companies. Thus, funding is not a main determinant for their AM business models. Additionally, all companies included in the study (either directly or as founders of the spin-offs and joint ventures) have core businesses which are not directly focused on AM. Still, all companies have core businesses which can be strongly related to AM technologies or could benefit from AM technologies. Therefore, AM business models for such companies are studied.

The study investigates the AM industry from a business model perspective. There are many theories describing the different components of a business model but here, the most defining and/or common components of business models are merged into three categories in order to increase the legibility. The categories are *value proposition, value creation* and *value capture*. These categories have further been equipped with subcategories developed by the authors but with a foundation in business model literature. The subcategories were developed in two different steps with the first step being the identification of the most relevant topics for the study and the second step the selection of which of the topics were feasible to investigate.

1.5 Research contribution

By addressing the research questions and purpose, this study contributes with knowledge and insight regarding how companies are facing the AM market. This will reduce the gap of lacking academic research from the managerial perspective of AM and contribute with benchmarking on possibly appropriate AM business models.
2

Literature study

This chapter starts with introducing additive manufacturing and its main benefits and challenges according to literature. This is followed by an introduction to Gartner’s hype cycle; what it is and how it can be used. The chapter ends with a review of business model literature and theory.

2.1 Additive manufacturing

Additive manufacturing (AM), commonly known as 3D printing, can be defined as the manufacturing of components layer-by-layer from 3D model data where each added layer represents a thin cross-section of the final part (Conner et al., 2014; Frazier, 2014; Gibson et al., 2010). In other words, the material is added gradually and thus, AM differs from traditional manufacturing technologies such as subtractive processes (drilling and milling etc.), joining processes (welding and fastening) and formative processes (casting and forming) (Conner et al., 2014). More, AM does not require any process planning (Gibson et al., 2010) and is applicable to a broad spectrum of materials, for example metals, polymers and ceramics (Frazier, 2014). However, even though the concept of AM was introduced over two decades ago, it has just recently begun to take position as a commercially important manufacturing technology (Frazier, 2014).

Frazier (2014) calls AM a transformative technology. Among others, he predicts AM to have a large impact on future business models since the technology holds the potential of highly affecting component design, product delivery and costs as well as increasing energy efficiency and lowering the environmental impact of manufacturing (Ben-Ner & Siemsen, 2017; Frazier, 2014; Bacchetti et al., 2016). Others are more skeptical to the potential of AM: Mendonca et al. (2017) argue that even though AM holds great promise, the short-term expectations are exaggerated. Conner et al. (2014) agrees with this statement and stress that business leaders must be aware of this when deciding if AM holds a business case for them.

In the following subchapters, the AM process and the most common AM technologies will be presented followed by findings and further expectations on AM from academia, for example the main benefits and challenges of AM.
2.1.1 The additive manufacturing process

Most AM processes can be summarized as consisting to a certain degree of eight steps (Gibson et al., 2010). These are introduced and described below:

1. **Conceptualization and CAD** – All AM components begin with a software model which fully describes the external geometry. Some AM methods require that the component is designed with additional support structures. These need to be removed after the part is printed. Commonly, a CAD (computer-aided design) modelling program is used for the design with the output being a 3D solid or surface representation. Another method for achieving the same output is reverse engineering through, for example, optical- or laser scanning.

2. **Conversion to STL** – This step involves converting the file to a, so called, surface tessellation format (STL) which serves as a basis for calculation of the layers. STL is the standard file format and nearly every AM machine accepts it.

3. **Transfer and manipulation of STL file to AM machine** – The STL file is transferred to the machine. Sometimes, the transfer requires manipulation of the file to ensure it has the right orientation, size and position for the build-up.

4. **Machine setup** – The machine is set up. The settings can include setting up the right process parameters such as material constraints and layer thickness.

5. **Building** – The building of the component is an automated process which the machine can carry out without much supervision. Only brief supervision is required to ensure that no errors have occurred (for example a power break or that the material has run out). The dimensional accuracy, surface finish and tolerances of the design depend on the specific AM technology that is used.

6. **Removal from machine** – After the component has been printed, it must be removed from the machine. This step can require some interactions with the machine, for example to ensure that the temperature is sufficiently low or that the machine activity is finished. In most cases, the unused material is recycled to the production after the build-up is finished.

7. **Post-processing** – Current AM technologies are not capable of producing net-shaped components, so after the component has been removed from the machine, it often requires additional post-processing before it can be used. This is needed for example due to the stair-stepping effect that comes from printing the layers or due to support structures that needs to be removed. Thus, common examples of post-processing steps are support structure removal and heat treatment. Even though AM can allow for better net-shaped components than traditional manufacturing technologies, the post-processing is still often time-consuming and requires careful manual manipulation. Therefore, it is key that AM is integrated in a supporting production system.

8. **Application** – After post-processing, the component is either ready to be used or it might need additional treatment such as priming or painting, before it reaches an acceptable surface finish. (Atzeni & Salmi, 2012; Gibson et al., 2010; Hao et al., 2014; Metallic Materials, 2017; Bacchetti et al., 2016)
2.1.2 Additive manufacturing technologies

All of today’s commercialized AM machines have in common that they use a layer-based approach. However, they differ through which materials can be used and how the layers are built and bonded to each other (Gibson et al., 2010).

The three most common AM technologies are powder bed fusion, binder jetting and directed energy deposition (SmarTech, 2017). Both powder bed fusion- and binder jetting technologies use a powder bed where the component is embedded in powder during the printing. Powder is added to the bed layer-by-layer and the printing is performed on each layer as a cross section of the component. For binder jetting, no support structures need to be added to the component since the support from the powder bed is sufficient. For powder bed fusion technologies on the other hand, the component requires support structures despite the powder bed. Another difference between powder bed fusion and binder jetting is that the former uses an electron- or laser beam to fuse the powder, while the latter uses a binder that works as an adhesive. As described above, the adhesive is spread between each powder layer, forming a cross section of the component. After the printing, the binder jetted component is in a so-called green state and therefore requires sintering. (Additive manufacturing research group, 2018; Gibson et al., 2010)

Directed energy deposition is a more complex process which is mostly used to add material to, or to repair, existing components. The basic principle is that the material, in the form of a metal wire or metal powder, is being deposited from a nozzle, typically mounted on a multi axis arm, onto existing surfaces of the part. Powder bed fusion- and binder jet printing are performed in printing chambers in AM machines which leads to components manufactured with those technologies being subjected to size limitations from the size of the printing chamber. Directed energy deposition is not performed within a printing chamber and is therefore not subjected to any size limitations. On the other hand, directed energy deposition provides the lowest surface finish among the three. (Additive manufacturing research group, 2018; Gibson et al., 2010)

Besides powder bed fusion, binder jetting and directed energy deposition, there are several niche technologies for metal AM. These include for example ultrasonic consolidation, inkjet-based methods and binder jetting alternatives. (SmarTech, 2017)

2.1.3 Main benefits of additive manufacturing

AM is frequently referred to as a revolutionizing technology with a range of benefits compared to traditional manufacturing technologies (Atzeni & Salmi, 2012; Frazier, 2014; Bacchetti et al., 2016). The main benefits of AM are commonly connected to either the design and engineering of components, the manufacturing process or the value chain. These are summarized in table 2.1 and further elaborated below.
Table 2.1. Summary of the main benefits of AM.

<table>
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<tr>
<th>DESIGN AND ENGINEERING</th>
<th>PROCESS</th>
<th>VALUE CHAIN</th>
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<tbody>
<tr>
<td>- Cost savings</td>
<td>- Allows for small batches or “batches of one”</td>
<td></td>
</tr>
<tr>
<td>- Design freedom and complexity at no extra cost</td>
<td>- Free customization</td>
<td></td>
</tr>
<tr>
<td>- Increased performance, such as reduced weight</td>
<td>- No tooling required</td>
<td></td>
</tr>
<tr>
<td>- New functionalities</td>
<td>- Allows for local production</td>
<td></td>
</tr>
<tr>
<td>- Part consolidation</td>
<td>- Elimination of assembly steps</td>
<td></td>
</tr>
<tr>
<td>- Reduction of waste</td>
<td>- Reduced need of warehousing, transportation and packaging</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Shorter lead times</td>
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**Design benefits**

Despite AM still being a relatively immature technology, it already has strong characteristics which makes it differ from traditional manufacturing technologies with regards to which products that can be produced. This since the layer-by-layer manufacturing of components removes design complexities as a barrier for production. For example, AM enables part consolidation, which means that several components can be manufactured in one piece instead of being manufactured separately and then assembled at a later stage. Further AM enables features such as variable wall thicknesses, blind holes, and high strength-to-weight ratios. This means that the functionality of the product is not sacrificed due to manufacturing or processing limitations. Instead, component functionalities can be significantly increased. (Bacchetti et al., 2016; Conner et al., 2014)

When the design can be perfectly optimized into complex geometries, it results in the reduction of waste, weight and resources. This in turn can lead to cost savings which can make the investment of redesigning previously traditionally manufactured components for AM an attractive option (Atzeni & Salmi, 2012; Bacchetti et al., 2016; Conner et al., 2014).

**Process benefits**

There is not yet a unified approach regarding how to measure the costs of AM processes (Bacchetti et al., 2016) and opinions also differ on how costs are affected by the use of AM. However, academia has agreed upon that by using AM, the unit costs are constant and independent of the production scale, as opposed to traditional manufacturing technologies where unit costs decrease with scale (Ben-Ner & Siemsen, 2017; Conner et al., 2014). Thus, AM enables small production batches (or batches of one).
The constant unit costs which are achieved with AM are especially beneficial when it comes to customized and/or complex products. Still, the ability to design and produce customized solutions is not new - AM simply makes it easier. In traditional manufacturing, the challenges with high customization have been, and still are, the costs of tooling, fixturing, dies and setups which all increase with an increased level of customization. Thus, while the unit costs for traditional methods are highly impacted by additional tooling or low part volumes, this is a non-existing problem for AM. This since with AM, not only customization but also complexity, as discussed above, is free. Figure 2.1 displays the cost difference between AM and traditional manufacturing technologies with the relation between cost per part and level of complexity or customization. (Ben-Ner & Siemsen, 2017; Conner et al., 2014)

Due to the constant unit costs, leveraging economies of scale is of less importance for AM. In turn, it becomes easier for smaller actors to challenge incumbents, especially in areas where customization, complexity and variation are highly valued and where customer lead times are critical (Ben-Ner & Siemsen, 2017).

Value chain benefits
AM cost savings will be further enabled through less delays in the production process. This since when using AM, the production can start directly after the design has been finalized. Thus, there are no costly delays from tooling which, with traditional manufacturing technologies, normally takes weeks. Tooling activities are subjects of large costs and a reduction (or elimination) of those would therefore lead to considerable cost savings and reduced lead times. (Atzeni & Salmi, 2012)

Except for the above-mentioned areas subjected to cost savings, AM also eliminates costs for line balancing and production bottlenecks due to its just-in-time nature. More, since AM offers the possibility to manufacture components without using auxiliaries such as jigs, fixtures and tooling, it is also argued to allow for production of components near the customers’ geographical location. This would mean that also warehousing, transportation and packaging would be reduced, and small sized
manufacturers close to customers would be more attractive than manufacturers in distant countries, which are often used for traditional manufacturing technologies due to cost advantages (Bacchetti et al., 2016; Ben-Ner & Siemsen, 2017).

Further, AM also gives designers the chance to build products in one single part instead of using assemblies, which are often needed when working with traditional manufacturing technologies. This is, for example, because nesting components, which otherwise would have to be assembled in multiple steps, can be printed simultaneously. Thus, with the use of AM, several steps can be eliminated from the value chain as compared to traditional manufacturing technologies. (Atzeni & Salmi, 2012; Bacchetti et al., 2016; Conner et al., 2014).

2.1.4. Main challenges and limitations with additive manufacturing

As made clear in the previous subchapter, AM offers several benefits. However, due to its immaturity, the AM technologies also bring plenty of challenges and limitations which, as the benefits of the technology, often are connected to either the design and engineering of components, the manufacturing process or the value chain. The main limitations are summarized in Table 2.2 and further elaborated below.

| DESIGN AND ENGINEERING | - High costs for materials  
|                         | - Lack of AM design skills  
|                         | - Lack of standards  
|                         | - Limited range of materials  
|                         | - New design approach required  
| PROCESS                | - High costs for machines  
|                         | - Immature technology and poor performance of machines  
|                         | - Intellectual property concerns  
|                         | - Limited component size  
| VALUE CHAIN            | - Complex supporting equipment and processes might limit possibilities for local production  
|                         | - Lack of competence  

Table 2.2. Summary of the main challenges and limitations with AM.

Design and engineering challenges

The most frequently mentioned challenge with the design of AM products is that it requires a new mindset from designers. Many designers struggle to reinvent their thinking in order and develop their skillset to exploit the possibilities of AM and reap the benefits of it. (Atzeni & Salmi, 2012; Frazier, 2014; Bacchetti et al., 2016)

Another current barrier of AM is that the technology is relatively limited when it comes to the available materials. Currently, the material is mainly supplied from
machine manufacturers together with the machines and since the machine manufacturers in most cases do not have materials as one of their core competences (the material is considered an add-on to the core offering which is the machines), the range of materials to choose from is limited. Thus, there is a need for new alloys to be developed to optimize component properties. In addition, some argue that the price of the materials is too expensive, and it is argued that this cost is one of the main determinants for whether AM can become more economically viable. (Atzeni & Salmi, 2012; Frazier, 2014; Hao et al., 2014; Bacchetti et al., 2016)

Further, it is argued that due to the current immaturity of AM, there is a lack of available standards. Standards are critical to ensure machine-to-machine consistency and the proper calibrations to achieve optimal performance. More, they are in some industries important for certifications. Therefore, a lack of standards can work as a barrier to enter the AM market and if more standards would be available, it would likely lead to a broader adoption. (Dobner et al., 2017; Metallic Materials, 2017).

Process limitations
As mentioned above, a frequently discussed limitation of AM is the current immaturity of the technology. This in turn makes it hard to control the process and outputs; for example, to control the dimensional accuracy, tolerances and surface finish. Further, the size of components manufactured with some AM technologies is limited due to the size of the printers available on the market. In addition, the AM machines are considered too expensive and the build-up process for AM components is still relatively slow. (Atzeni & Salmi, 2012; Metallic Materials, 2017; Hao et al., 2014)

Further, AM has initiated a discussion regarding intellectual property (IP) concerns such as ownership of designs, component counterfeiting and copying of components through 3D scanning (Cass & Kurfess, 2015). Wilbanks (2012) compares the concerns regarding AM’s IP to the problems that the music industry faced during the introduction of the internet. The music industry then struggled with illegal downloads while the AM industry is predicted to struggle with the fact that components can be copied easily using 3D scanners. Further, Andel et al., (2014) stress that the high degree of computerization of the AM process will make the it an attractive target for hacker attacks. The designer and the manufacturer of AM components must both have access to the IP in order to produce AM components, but in the case of outsourcing, the IP is protected solely by contractual agreements. However, several examples have shown that contractual relations are not sufficient for protecting companies from IP violation and thus, actors must consider how to protect their IP when entering the AM market (Andel et al., 2014).

Challenges connected to the AM value chain
Mendonca et al. (2017) argue that it is a myth that AM will make manufacturing more local, or at least that this scenario is highly exaggerated. This since it takes both skilled
workers and extensive and sophisticated equipment to produce reliable AM components. Therefore, it would not make sense to have ten different locations using one operator each; it would be more cost-efficient to have one person in charge of ten machines at one location. Further, AM often requires many advanced post-processing steps and complex tests requiring their own specialized machinery. An example is a simple titanium-alloy component for aerospace, for which the post-processing and test costs make up 10-15 percent of the total cost. For such components, it is clear that it is better to do the post-processing at one location. Therefore, Mendonca et al. (2017) argue that governments are making mistakes if they invest public money in AM in the hope of “bringing back manufacturing”. However, the possibility of using AM to streamline and accelerate product development is not denied. For prototypes, which often have less need for post-processing, local AM production is still considered an option. (Mendonca et al., 2017)

2.1.5. Adopters of additive manufacturing technologies

For actors evaluating whether to start using AM, it is important to make sure that the right technology is assigned to the right products. AM is for example ideal for products which are characterized by high variation and customization. This since the unit cost is constant for AM independently of the production volume as described above in the subchapter 2.1.3 Main benefits of additive manufacturing. AM is also a suitable technology in industries where product life cycles are short and where delivery lead times are critical. Two industries which are frequently pointed out as the ones gaining most benefits from AM are the aerospace industry and the medical/dental industry. These industries are both characterized by highly complex products where performance is critical and valued higher than low costs. Today, these are also the industries in which metal AM is most widely used (Ben-Ner & Siemsen, 2017; Hao et al., 2014; Bacchetti et al., 2016)

Recent analyzes from McKinsey & Co. and Boston Consulting Group also confirm that the aerospace- and medical/dental industry are the areas where AM is most widely adopted today (Bromberger & Kelly, 2017; Corman et al., 2017). Additionally, they mention the automotive industry as a key area for AM applications. This even though the automotive industry is characterized by higher cost sensitivity than the other previously mentioned industries. Still, it is predicted that these three industries will account for around 50 percent of the AM market by 2020 (Corman et al., 2017).

However, as AM grows and costs are decreasing, AM is believed to spread into other industries as well. Examples are oil and gas, robotics and an even wider spread within automotive. First, AM is believed to penetrate markets with critical timelines, then it will move into general production of small components made of expensive materials (since one of the main benefits with AM is that it allows for significant material reduction). Thereafter, the further spread of AM depends on how fast it will be able to compete with existing technologies regarding costs. (Chalabyan et al., 2017)
Further, for many industries, AM is suggested to be a suitable technology for prototyping and on-demand production of spare parts. For spare parts, product variety is enormous and if the parts are manufactured through traditional manufacturing technologies, they must be kept in inventory even though they have long gone out of production (since the spare parts are then produced together with the initial parts to reduce costs). Further, AM is suitable for spare parts since they are often ordered as a response to a breakdown. Thus, lead times are critical. (Ben-Ner & Siemsen, 2017; Conner et al., 2014; Corman et al., 2017; Bacchetti et al., 2016)

Many also believe that platforms, on which actors can build and connect, will be the future of AM. Therefore, becoming a successful platform provider is a strategic goal for many actors in the AM industry. The reason why platforms are believed to be a prominent feature of AM over time is that the production itself is predicted to become less important as it matures. Further, AM components might be efficiently produced on demand in so-called “printer farms” and the digital designs of the components will be hard to protect, as was previously discussed in the subchapter 2.1.4. Main challenges and limitations with additive manufacturing. However, it is argued that the platform owners, who control the digital ecosystems, will be in highly powerful positions in the middle of a vast volume of industrial transactions. (d’Aveni, 2015)

2.1.6. Implementation and change driven by additive manufacturing

It is shown that the intensity of user-supplier interaction processes increases with the complexity of a technological innovation. Therefore, it is argued that for AM to deliver its full potential, considerable organizational change is required. For example, the relations between suppliers and customers need to take more collaborative forms. Further, it is also recognized that vendor support is a critical factor for the success of implementing a new technology and this will likely be the case also for AM implementation. (Hao et al., 2014)

Further, there is no one-size-fits-all strategy for AM; each organization needs to develop its own strategy based on its unique capabilities. For example, the size of an organization has been identified as a critical factor for understanding the implementation of a new manufacturing technology. Thus, smaller organizations cannot be considered as scaled-down larger ones and the theories which have been proven to work in large organizations might not suit smaller ones. (Hao et al., 2014).

A predictive article by Ben-Ner and Siemsen (2017), which summarizes the most radical anticipations of AM, states that with AM, “global will turn local; mega will become mini; long supply chains will shrink; many jobs will be broadened to combine design, consulting, sales, and production roles; and large organizations will make room for smaller ones.” In other words, AM supply chains are argued to be drastically simplified compared to the supply chains in traditional manufacturing (Ben-Ner & Siemsen, 2017; Hao et al., 2014).
2.2 Gartner’s hype cycle

One of the most common tools for mapping the expectations of new technologies is Gartner’s hype cycle (Leifer & Steinert, 2010; Gartner, 2018). The Gartner Group is a company specializing in providing research about information technology to the subscribers of their publications. The information regards, for example, how different technologies are likely to influence the market and which technologies might be favorable to adopt (Dedehayir & Steinert, 2016; Leary, 2008). As part of this, Gartner has developed several frameworks to help evaluating technologies, one of those being the hype cycle. The hype cycle was introduced in 1995 and has since received considerable attention from industry (Dedehayir & Steinert, 2016). However, the interest from academia has been limited until the recent decade, especially within technology and innovation management.

Gartner’s hype cycle, displayed in figure 2.2, consists of five different phases which new technologies go through as they reach maturity. The phases are:

1. **Innovation trigger** – a new technology steps into the first face of the hype cycle when it gains attention, commonly through early proof of concept cases and/or media reporting. In this stage, there are usually no usable products and the commercial viability of the technology is not yet proven.

2. **Peak of inflated expectations** – after the first reporting, success stories of using the technology starts getting attention through early publicity. However, there is still limited information about the technology and how it can be applied in practice. In this phase, some actors take action and start adopting the technology, but most are still hesitant.

3. **Trough of disillusionment** – after being on top of the hype curve, gaining a somewhat increased adoption, cases where the technology implementation and experiments have failed start appearing and the interest in the technology fades. Thus, the expectations from the second phase were impossible to live up to. From this stage, further investments in the technology will only happen if the surviving providers of the technology improve the technology enough to satisfy early adopters.

4. **Slope of enlightenment** – more areas of application for the technology emerges and it reaches a wider understanding due to focused work and experimentation from a diverse range of actors. Also, second or third generations of the technology are released, and the technology starts receiving more funding. Conservative actors are still hesitant.

5. **Plateau of productivity** – when entering the last phase of the hype cycle, the technology has reached mainstream adoption and criteria for assessing viability of providers are becoming clear. The technology has now reached a broad market applicability. (Gartner, 2018; Leary, 2008; Leifer & Steinert, 2010)
For organizations evaluating the promise of a new technology, Gartner’s hype cycle can be a helpful tool. It can also be used for evaluating risks and help organizations assess whether it is worth to take the risk of investing in a technology, if it is better not to invest, or wait until the technology has matured further. According to Gartner, it might be better to wait until the technology has delivered tangible results if an organization considers that there are too many unanswered questions regarding commercial viability. (Gartner, 2018)

In 2012, AM in general (it was not stated whether the mapping regarded metal or polymer AM) was pictured at the very peak of Gartner’s hype cycle, thus in the second phase (Fenn & LeHong, 2012). This indicates that currently, the expectations of AM were at their highest – and probably also unrealistic (Gartner, 2018; Leary, 2008).

2.3 Business models

In this chapter, the concept of business models and its key components will be elaborated. Further, it will be illustrated how organization can work with business model experimentation to create and deliver value to customers.

2.3.1 The key components of a business model

As companies adopt new technologies and new organizational structures, while at the same time deal with existing workforce and structures, exploration of new business models will become increasingly important (Ben-Ner & Siemsen, 2017). A business model articulates how organizations generate revenue and is also the underlying explanation for how organizations create and deliver value to their customers (Afuah et al., 2017; Osterwalder and Pigneur, 2010; Teece, 2010). The
The value of a technology remains hidden until it becomes verbalized through a business model and therefore, a suitable business model helps organizations to commercialize new ideas and technologies out of which the economic outcome will differ using one model or another. Thus, it is important for organizations to develop capabilities to innovate their business models (Chesbrough, 2010).

There is more than one way of articulating how organizations create and deliver value to customers proposed throughout business model literature. The common denominator however is that the business model should articulate “the architecture of the value creation, -delivery and -capturing mechanisms” (Teece, 2010), or in other words, what to offer, to whom and how to generate revenue out of it (Schön, 2012). Over the past decades, over 40 different components have been included in various business model definitions, differing across industries (Sinfield et al., 2012). However, some key components exist (Brunswicker et al., 2013). According to Engwall and Tongur (2014) the essence of a business model can be compiled into three categories: *value proposition*, *value creation*, and *value capture*. These are illustrated in figure 2.3 below together with respective definitions and examples of sub-categories.

<table>
<thead>
<tr>
<th>VALUE PROPOSITION</th>
<th>VALUE CREATION</th>
<th>VALUE CAPTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong> the value of the products and services offered (Engwall &amp; Tongur, 2014)</td>
<td><strong>Definition:</strong> how the value of the products or services is created (Engwall &amp; Tongur, 2014)</td>
<td><strong>Definition:</strong> how the organization can retain the value it has created for customers (Engwall &amp; Tongur, 2014)</td>
</tr>
<tr>
<td><strong>EXAMPLES:</strong></td>
<td><strong>EXAMPLES:</strong></td>
<td><strong>EXAMPLES:</strong></td>
</tr>
<tr>
<td><em>The product/service offering:</em> the bundle of products and services that creates value for customers (Osterwalder &amp; Pigneur, 2010);</td>
<td><em>Core assets and capabilities:</em> the most important assets and capabilities required for value creation, such as physical, intellectual, human or financial assets (Osterwalder &amp; Pigneur, 2010; Schön, 2012);</td>
<td><em>Customer relations:</em> the type of relationship the organization wants to establish with its target customers. Defining customer relations can be driven by the motivation of customer acquisition, customer retention or to boost sales. Examples of customer relations are self-service (no direct relationship) and co-creation (to co-create value with customers). (Osterwalder &amp; Pigneur, 2010);</td>
</tr>
<tr>
<td><em>Target customers:</em> the customer and customer needs that the company want to serve (Schön, 2012);</td>
<td><em>Key activities:</em> the most important activities the organization engage in to realize the business model (Osterwalder &amp; Pigneur, 2010);</td>
<td><em>Pricing:</em> pricing logic applicable for target customers (Schön, 2012);</td>
</tr>
<tr>
<td><em>Geographical areas:</em> countries and areas which the organization wants to do business in (Schön, 2012).</td>
<td><em>Partnerships:</em> the network of suppliers and partnerships required for value creation. (Osterwalder &amp; Pigneur, 2010; Schön, 2012). Four types of partnerships have been identified by Osterwalder &amp; Pigneur (2010): strategic alliance between non-competitors, strategic partnerships between competitors, joint ventures to develop new businesses, buyer-supplier relationships to assure reliable supplies. Having alliances can help companies to optimize their business models and to reduce risks (Osterwalder &amp; Pigneur, 2010).</td>
<td><em>Channels:</em> how the organization communicates with and reaches its customers. Finding the right mix of channels to satisfy how customers want to be reached is important to bring the value proposition to the market (Osterwalder &amp; Pigneur, 2010).</td>
</tr>
</tbody>
</table>

**Figure 2.3.** The three main categories of a business model with respective definitions and examples of sub-categories.
### 2.3.2 Designing a business model

Business model innovation, meaning innovation where more than one component of the business model is “reinvented to deliver value in a new way” (Deimler et al., 2009), can be a pathway to a competitive advantage. This since the creation or refinement of a business model often has the outcomes of lower costs or increased value to customers, as long as it is not easily replicated by competitors (Teece, 2010). An important factor in the creation of a business model is therefore its non-imitable design (Kindström, 2010; Teece, 2010).

Three factors have been identified as relevant for impeding copycat behavior of the business model. Firstly, when implementing a business model, systems, processes and assets which are hard to replicate are often required. An example of this is that due to a lack of the right capabilities and patents, Blockbuster failed to replicate Netflix’s offering of shipping DVDs by mail. Secondly, the business model should hold a level of opacity so that it becomes hard for competitors to get a detailed view of how it is implemented. Lastly, even if the components of the business model are obvious for a competitor to replicate, they might be reluctant to do so if that would involve cannibalizing existing sales and profit or harming current business relations. When competitors are constrained in this way, the pioneer of a new business model might enjoy a period of limited competition. If these constraints are notwithstanding, the competition is likely to become though over time due to new entrants who are not constrained by incumbency and anxiety concerning cannibalization, and thereby can enter more freely (Teece, 2010). However, in a study by Mitchell (1991), which investigated market size in relation to entry timing amongst incumbents and newcomers, it was found that industry incumbents are mainly affected by other incumbents when entering new markets, while newcomers are influenced by all entrants to the market (Mitchell, 1991; Teece, 2007).

As a new industry evolves, both incumbent companies and newcomers must decide if they want to enter the market at an early stage, wait until other companies have tested the technology and market, or not to enter the market at all. Entering the market early brings the risk of the technology turning out to lack value, while actors entering the market at a late stage can incorporate early research at lower costs but also face the risk of being frozen out by actors who took the risk of early market entry (Mitchell, 1991). Mitchell (1991) concludes that lower market shares are associated with late entry for incumbents, relative to other incumbents. Early entrants, on the other hand, tend to attain greater initial market share and gain long-term market share if they survived. Further, industry incumbents tend to perform better if they first let newcomers test new markets. Even though other factors except for entry timing also affects performance and market share, entry timing influences are significant (Mitchell, 1991).
Along with the business model being hard to replicate, there are several other factors to take into consideration in the design process of a business model. According to findings by Teece (2017), this includes:

- Intuition, science and analysis are equally important in a good design;
- An understanding of the current business models in the market is required as new designs often involve jointure of others;
- A good business model design requires deep knowledge in customer needs;
- Identifying the customer segments to initially focus on to ensure business model viability is critical;
- A separate organizational unit is recommended when introducing a new business model (Teece, 2017).

*Business model experimentation*

Traditionally, there are three different ways in which companies can pursue growth: investments in product development to produce better offerings; developing customer insights to satisfy customer needs in a better way; and growing through acquisitions or moving into new markets (Sinfield et al., 2012).

These traditional ways of pursuing growth often require investments in both time and resources for developing organizational competences, for example through investments in R&D and setting up strategy units. However, in addition to the aforementioned growth strategies, a fourth path named “business model experimentation” has recently emerged (Sinfield et al., 2012). Business model experimentation is about pursuing growth through exploring alternative business models, quickly finding alternative value creation approaches, and treating the business model as a variable instead of a constant. The reason for doing so is to lower the risk of taking the wrong or less potential road with only a relatively small investment. This is done by identifying how to create most value for customers and for the company itself. Further, business model experimentation allows managers to anticipate, adjust and capitalize on new technologies and customer insights and thereby make better informed decisions on how to compete (Sinfield et al., 2012; Chesbrough, 2010).

Even though business model experimentation is important and can lead to several benefits, some experiments should be expected to fail. However, trying out alternative business models on real customers with real economic transactions provides high fidelity, and even if the experiments fail, they still lead to new data that can be used to update financial projections and generate data which can give directions towards previously latent opportunities (Chesbrough, 2010; Thomke, 2003). Commitment to business model experimentation is also by Chesbrough (2010) considered appropriate when it is not clear how the “right” business model should be outlined. By doing experiments early and often, managers can collect
information when it is least expensive and increase the amount of information serving as basis for decisions (Thomke, 2003).

Further, creating a business model is complex and the design process is likely to be iterative (Teece, 2010). Deciding what elements to incorporate in the business model and trying different combinations of the elements can be a quick and robust way of exploring an organization’s possibilities as new combinations, which have not been seen before in the industry, might be revealed (Sinfield et al., 2012; Chesbrough, 2010).

A starting point in the business model creation is to decide the company’s offering. As an option to asking the question “what should we sell?” when designing the value proposition, the question could be broken down into a set of sub-questions such as:

- Should we sell a product or a service?
- Should the offering be standard or customized?
- Will the offering’s benefits be tangible or intangible? (Sinfield et al., 2012).

The possible answers to these and similar questions, such as “how large is the target segment?”, “what might customers be enticed to pay for the value delivered?” (Teece, 2017) or “which customer needs are we satisfying?” (Osterwalder & Pigneur, 2010), can further be examined to form a series of options for outcomes. A promising approach to do business model experiments is to then construct maps of business models and to consider alternate combinations of their underlying components (Chesbrough, 2010). The possible answers to additional posed questions connected to different sections of the business model can be selected and linked to investigate how different combinations can create different outcomes. An example of this approach is displayed in figure 2.4 (Sinfield et al., 2012).

<table>
<thead>
<tr>
<th>Who should be our target customer?</th>
<th>What customer need should we fill?</th>
<th>What offering will satisfy that need?</th>
<th>How will customers access our offering?</th>
<th>Where should we operate in the value chain?</th>
<th>How will we earn profit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer 1</td>
<td>Job 1</td>
<td>What we sell 1</td>
<td>How we sell 1</td>
<td>Value chain role 1</td>
<td>How we profit 1</td>
</tr>
<tr>
<td>Customer 2</td>
<td>Job 2</td>
<td>What we sell 2</td>
<td>How we sell 2</td>
<td>Value chain role 2</td>
<td>How we profit 2</td>
</tr>
<tr>
<td>Customer 3</td>
<td>Job 3</td>
<td>What we sell 3</td>
<td>How we sell 3</td>
<td></td>
<td>How we profit 3</td>
</tr>
</tbody>
</table>

Figure 2.4. Examples of questions to ask when designing the business model along with the interlinking of answers leading to different outcomes based on Sinfield et al. (2012).
When investigating different combinations of variables in the business model, it becomes clear that some are interrelated. This in turn reduces the number of possible business models to investigate further. More, it should be noted that changing one component can lead to an outcome of a substantially different business model. Additionally, the outcome will also be limited by the organization’s strategic objectives as some answers will automatically not be viable if the organization wants to stay aligned with its initial strategy (Sinfield et al., 2012).

A way of determining the relevance of the different answers to questions such as those presented in figure 2.4, is to mark them as “desirable”, “discussable” and “unthinkable” (Sinfield et al., 2012). Doing so will help to clarify strategic goals and to streamline efforts. It may also encourage ideas which previously would be considered as out of bounds but at another point in time could be discussed. More, this discourages wasting time on what is considered unthinkable options (Pal & Pantaleo, 2008). Figure 2.5 provides a visual explanation of this framework.

![Figure 2.5. Clustering ideas into different categories based on Sinfield et al. (2012).](image-url)

Business model innovation is an activity which not all companies succeed with and therefore, it can act as a source of competitive advantage (Sinfield et al., 2012). By engaging in business model experimentation, organizations can understand the implications of different business models and learn how and where they want to compete. It also enables organizations to identify which business model create most value for the customers and themselves and thereby, they can use their resources in a more efficient way. Finally, business model experimentation allows organizations to extract maximum potential from other growth-focused activities such as R&D and strategic development efforts. (Sinfield et al., 2012)
3

Research design and methodology

This chapter presents the research design and introduces the case study. Further, this chapter also describe how the data was collected and analyzed through the study. The chapter then ends with a discussion concerning the reliability, validity, generalizability and ethics of the methods used and of the results.

3.1 Research design

This study is of an exploratory character as there are few previous studies which can provide insight and information about the problem. The aim of an exploratory study is to gain insights and familiarity with an area which has not been scientifically studied to a large extent, by looking for patterns and ideas rather than testing a hypothesis. Exploratory research rarely provides conclusive answers to posed problems but instead suggest if, and in that case what, further research should be conducted (Collis & Hussey, 2014). The exploratory approach was chosen since AM still is immature relative to other manufacturing technologies and the information about AM business models both from the industry and from research is limited. In combination with the exploratory purpose, the study had an inductive approach. The inductive approach can be described as collecting empirical data based on an identified problem and then use relevant theories to increase understanding of the results (Blomkvist & Hallin, 2014; Collis & Hussey, 2014).

As displayed in figure 3.1, the research process involved several activities which were performed in parallel. The study includes multiple cases with both internal interviews at the commissioner company and with external interviews. Pre-study interviews of an open character were first conducted at the commissioner company to get an understanding of the overall problems and the AM industry as a whole. Having open, unstructured interviews is recommended in the beginning of an empirical study to explore the topic without prejudice (Blomkvist & Hallin, 2015). At the same time, an extensive initial literature review was conducted with a primary focus on peer reviewed articles. Along with these articles, consulting reports and relevant industry articles were also consumed to gain market insights and thereby identify research gaps.
To accumulate data to answer the research questions, semi-structured interviews were conducted with representatives working with AM at six different companies and two universities. For triangulation purposes, at least two representatives were interviewed from each company. The answers from the interviews were analyzed in two steps and categorized into a business model framework created by the authors. The framework was developed with inspiration from frameworks originating from business model theory (Engwall & Tongur, 2014; Osterwalder & Pigneur, 2010; Schön, 2012; Sinfield et al., 2012), but which were altered and combined to be relevant for the investigated parties and research questions. Therefore, the framework is in many aspects similar to other business model frameworks.

Throughout the research process, an iterative approach was adopted, meaning that the research questions and the problem formulation were updated and adjusted continuously. Further, theories were also consumed iteratively throughout the process, as suggested by Collis and Hussey (2014). This helped to increase the understanding of both the theory and the empirical findings, thus allowing a deeper analysis with support from both sides.

3.2 Multiple case study

The case study method is generally preferred when “how” and “why” questions are posed, when the investigator has little control over events and when the study focuses on a contemporary phenomenon in a real-life context. Data collection methods are often combined in case studies and can consist of, for example, interviews, surveys and observations where the results can be either qualitative (words), quantitative (data), or a combination of the two (Eisenhardt, 1989). The case study method is used in many situations to contribute with
knowledge about individual, group, organizational, social or political related phenomena (Yin, 2009). Some have been critical to case studies as the investigators may collect data with subjective judgments. The case study method is a challenging method which leads to many variables and therefore, it is critical to use multiple sources of evidence where the data needs to converge in a triangulating way (Yin, 2009).

Conducting a multiple-case study have substantial analytical benefits compared to single-case studies as the analytical conclusions independently arising from the different cases will be more powerful than those from a single case alone (Yin, 2009). The results from a multiple case study are often considered as more compelling and therefore, this method can be regarded as more robust (Yin, 2009). In this study, a multiple-case approach is appropriate since the study aims at creating an understanding of the overall AM industry rather than investigating the direction of one single company.

3.2.1 Selection of case companies

To increase the validity of the study, the case companies all needed to fulfill some criteria: the case companies should all be either large organizations placing heavy investments into AM, or spin-offs or joint ventures of such organizations. A common denominator is further that all companies included in the study should have large funding for their AM initiatives so that monetary resources is not the primary factor deciding the business model. Further, all companies should have, or originate from, a core business which is not AM. The respective companies’ core businesses vary but they are all connected to the AM value chain in various ways. Examples of core businesses of the case companies are metal post-processing, design software for manufactured components and material production. In addition to the case companies, researchers within AM from two of Sweden’s top universities were interviewed, since they meet with many companies and thereby can provide insight to the AM market.

The investigated companies, labeled Company A-F in this report, are companies in the forefront of the Swedish manufacturing industry. One of the case companies is the commissioner of this report. All companies thereby have solid knowledge of the manufacturing industry, even though their internal AM capabilities vary. Table 3.1 presents the companies and researchers which contributed to the study’s empirical findings. Due to an anonymous character of the study, the interviewees will be referred to solely by their functions. However, to facilitate the reading of the report, the functions have been abbreviated and therefore, the column Abbreviated function has been added to table 3.1 below. The abbreviations have been made by the authors.
Table 3.1. Summary of interviewees and their respective organization types and functions.

<table>
<thead>
<tr>
<th>NAME OF ORGANIZATION</th>
<th>ORGANIZATION TYPE</th>
<th>INTERVIEWEE FUNCTION</th>
<th>ABBREVIATED FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>University A</td>
<td>University</td>
<td>Associate Professor and Responsible for University A’s AM research initiative</td>
<td>Professor</td>
</tr>
<tr>
<td>University B</td>
<td>University</td>
<td>Professor and Director of the University B’s AM Competence Centre</td>
<td>Research Director</td>
</tr>
<tr>
<td>Company A</td>
<td>Large company</td>
<td>President of the AM business area</td>
<td>President</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CTO of the AM business area</td>
<td>CTO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operations Manager of the AM business area</td>
<td>Operations Manager</td>
</tr>
<tr>
<td>Company B</td>
<td>Joint venture</td>
<td>CEO</td>
<td>CEO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sales Manager</td>
<td>Sales Manager</td>
</tr>
<tr>
<td>Company C</td>
<td>Spin-off organization owned by a large company</td>
<td>Board Member of the owning company</td>
<td>Board Member</td>
</tr>
<tr>
<td></td>
<td></td>
<td>General Manager</td>
<td>General Manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sales and Marketing Manager</td>
<td>Sales Manager</td>
</tr>
<tr>
<td>Company D</td>
<td>Large company</td>
<td>Additive Manufacturing Engineering Manager</td>
<td>Engineering Manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Advanced Manufacturing Engineering Leader</td>
<td>Engineering Leader</td>
</tr>
<tr>
<td>Company E</td>
<td>Large company</td>
<td>CTO</td>
<td>CTO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group Manager in the Additive Manufacturing Centre of Competence</td>
<td>Group Manager</td>
</tr>
<tr>
<td>Company F</td>
<td>Large company</td>
<td>Design Engineering Research Manager</td>
<td>Design Manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additive Manufacturing Manager at Business Development</td>
<td>Business Developer</td>
</tr>
</tbody>
</table>

3.3 Data collection

In this study, interviews worked as the means for data collection. Collecting data through interviews is one of the most common methods in qualitative social science research (Blomkvist & Hallin, 2015). It is a suitable method to use when one is interested in developing a deeper understanding of a phenomenon, to explore new dimensions of what one is studying and when one is interested in ambiguity. Conducting interviews is also a manageable way of gaining insights into how individuals reason about an issue and it provides the possibility to do unintended discoveries (Blomkvist & Hallin, 2015). As part of the case study, interviews were conducted throughout different stages of the study. All interviews except the pre-study interviews were semi-structured, meaning that the interviews were centered around themes and questions designed beforehand (Blomkvist & Hallin, 2015).

Pre-study interviews

To give the research process a solid start, six interviews of an open character were conducted at the commissioner company. The interviews were conducted with
representatives from different areas in the organization: pricing managers, business developers and marketing and sales managers were represented among others. Each interview lasted for about an hour. The primary aim of the interviews was to get a fundamental understanding of the organization and its environment through discussing its business model and the AM market. Another aim of the interviews was to outline the positioning of the study. The interview questions were all centered around general themes with their basis in the different components of a business model, but the dialogues were open. The pre-study interviews were all conducted face-to-face and were not recorded.

**Internal interviews**
After conducting the initial literature study, eight internal interviews were conducted with representatives at the commissioner company. The interviewees were interviewed one at a time and for 40-60 minutes each. Seven of the interviews were conducted face-to-face while one was conducted through an online call. Further, all interviews were semi-structured and the questions centered around themes based on the components of business model frameworks. However, there was more focus on certain business model components in which the answers from the pre-study interviews had been unclear or considered as more interesting. The aim of the internal interviews was to get answers to questions which arose from the pre-study interviews and to gather data for the multiple case study. In most cases, questions had been sent out to the interviewees in advance so that they could prepare. In some cases, the interviewee instead received a description of the topics to be discussed during the interview. All internal interviews were recorded and transcribed afterwards and all interviewees had given their consent to the recording.

Three of the interviewees were used as representatives for the multiple case study and are thus included in the analysis. Neither of these interviewees had been interviewed during the pre-study to give them the same conditions as the external interviewees who participated in the multiple case study.

**External interviews**
External interviews were conducted parallel to the internal interviews. The external interviews were also semi-structured and conducted either face-to-face or via online calls. The interviews lasted for 40-60 minutes. Further, the external interviews followed the same structure as the internal interviews. The aim of these interviews was to gather data for the multiple case study by getting an understanding for what the interviewees considered critical for AM business model success. Thus, the external interviews were also centered around themes based on the common components of business model frameworks. All external interviews except two were recorded and transcribed afterwards. In all cases where the interview was recorded, the interviewees had given their consent. In the two interviews which were not recorded, one of the interviewers focused on taking notes and the other interviewer focused on asking the questions.
3.4 Source criticism

A majority of the sources used for the literature review originate from peer reviewed journals. However, certain consulting reports are brought up in the report as well. These reports have mainly been used to gain an overview of the AM market and to get inspiration for future research. Examples includes benefits, possibilities and challenges associated with AM.

The sources originate deliberately from different time periods. As the AM market is relatively immature and evolving, the sources providing information about AM related areas are maximum only a few years old while sources regarding business model theory in some cases, but not all, are far older due to the fact that business model research has existed for a longer period of time and the core definitions and concepts have remained the same.

Criticism regarding the empirical sources should also be posed. There is a possibility that the interviewees brought up or criticized certain business model areas during the interviews due to their background and area of expertise, and thereby making the findings biased. Also, even though a majority of the interviews were recorded and transcribed, there is a risk that the responses have been misinterpreted by the authors, or that the interviewees misunderstood questions during the interviews. These limitations should be kept in mind when reading the report.

Further, since AM is still relatively immature, few AM business models have, to this date, been clearly defined within companies. This can lead to companies being reluctant to share sensitive information which in turn might have affected the study’s empirical data.

3.5 Data analysis

Analyzing data is the most difficult part of the research process (Eisenhardt, 1989). The collected data should be processed in a critical way through an open and reflective approach and not only be presented in its raw form (Blomkvist & Hallin, 2015). As the data gathered in this study is of a qualitative form, an inductive approach was applied where the analysis of the empirical data was done in parallel with developing a deeper theoretical understanding, as proposed by Blomkvist and Hallin (2015). Thereafter, a thematic analysis was done for the empirical data, meaning that the data was sorted into categories to help answer the research questions (Blomkvist & Hallin, 2015). The categories were developed in the beginning of the study with inspiration from Sinfield et al. (2012), figure 2.4 in chapter 2.3.2 Designing a business model, and clustered under value proposition, value creation and value capture. These categories were used to summarize the interviews. Also, with inspiration from the framework by Sinfield et al. (2012), the findings were marked in green, yellow and red to represent the certitude and confidence of the
statements, see figure 3.2. The reasoning behind the colors is further elaborated in chapter 4 *Empirics*.

![Business Model Framework](image)

**Figure 3.2. The first thematic business model analysis.**

This framework helped get an initial overview of the opinions from different interviewees and their recommendation for AM business models. However, a limitation when filling in the framework from recorded interviews is that the categorization of the responses was done based on how the interviewers interpreted the answers. As the study evolved, the sub-categories of the business model were altered and combined into 10 questions displayed in table 3.2 below. These categories were used also to summarize the interviews per company.

![Table 3.2](image)

**Table 3.2. Final sub-categories for business model framework.**

The study’s analysis process is displayed in figure 3.3. In order to answer the first research question, thus identifying common themes among the interviewees’ views on appropriate business models, the interviews were also analyzed in relation to each other, clustered under the main categories of the business model (value proposition, value creation and value capture). First, common themes among the companies’ and the universities’ statements were identified. Then, the statements from each interviewee, regarding each theme, were compared and analyzed in relation to each other to identify in which way they were similar or different. When the themes had been identified, it was suitable to look at their interrelations since different
combinations of the themes can create different business model outcomes (Sinfield et al., 2012). Also, different business model components can contradict each other and thereby not be possible to include in the same business model. Therefore, the alignment of the themes was analyzed after each business model category, aiming at answering the second research question.

Figure 3.3. The study’s analysis process.

3.6 Quality of the research

The quality of a study can be divided into two categories, the first is the study’s reliability and validity and the second is the generalizability of the study. Reliability refers to the study’s accuracy and precision, that is, if the same results would have been achieved if the study was repeated. Validity, on the other hand, describes if the researchers are studying the right phenomena and if the results reflect the phenomena which has been studied. Having a high validity and reliability makes the study more credible. Further, the study’s generalizability refers to the extent which the results of the study can be examined or applied beyond the study (to other cases and contexts). (Blomqvist & Hallin, 2015; Collis & Hussey, 2014)

3.6.1 Reliability

To ensure reliability of the study, the interviews were conducted with a minimum of two representatives per company. Some interviewees struggled with answering the questions from an industrial perspective and not an operational (company specific) perspective even if they were reminded of the general character of the study. This might have affected the reliability. On the other hand, by conducting at least two interviews with each company, it was possible to triangulate the information and thereby easier separate personal opinions from general company opinions. Also, since the study has a holistic business model perspective, most interviewees hold
positions at C-level or management level. This since they were believed to have the most holistic view over the companies’ respective business models and strategies.

The interviews were recorded, transcribed and analyzed to ensure that both the reliability but also the validity was high. However, the choice of using semi-structured interviews can be argued to lower the reliability since this method makes it harder to replicate the interviews. Also, since the interviews followed themes, rather than strictly following predetermined questions, different interviewees might have interpreted similar questions differently (Blomqvist & Hallin, 2015).

Further, the interviewees’ statements from the empirical findings of the study were divided into categories (green, yellow and red) in the analysis to illustrate the interviewee’s level of confidence and certitude. This was done to increase the legibility of the findings. However, this categorization depends to a large extent on how the authors have interpreted the statements and this subjectivity can be argued to decrease the study’s reliability. If the data would have instead been collected through, for example, questionnaires, it would have been easier to interpret the answers since it would have allowed the interviewees to grade different statements on a specified scale and thereby providing more comparable answers. By using this method instead, similarities and differences among the statements would have been even more apparent.

However, using semi-structured interviews was still considered as being the best option since it provides flexibility and opportunities to identify new interesting areas to investigate. Further, semi-structured interviews encourage an openness in the conversation which was desired since the questions touched upon strategic matters (Blomqvist & Hallin, 2015). Lastly, semi-structured interviews also let the interviewees discuss the areas which they found most interesting regarding the topic which made the identified common themes from the interviews more interesting. The interviewees were also given the possibility to read through what is presented from their interviews in the report, which increases the reliability of the results and the coloring of the summary.

3.6.2 Validity

To ensure validity of the study, the literature and theories have been carefully chosen to be aligned with the research question and purpose of the study. Further, mainly peer reviewed articles have been used to study the phenomena in the literature study. However, due to the immaturity of the AM industry, some non-peer reviewed reports, for example by consulting firms, have been used to get a broader and more up-to-date understanding of the industry and its challenges. However, these reports worked rather as inspiration for the work.
More, it can be argued that the anonymity of the case companies reduces the validity of the study. However, the companies included in the study are all main players in the AM industry and were frequently mentioned by each other as strong actors. Even though the validity perhaps would have increased if the companies were named, it was not viewed as an option since the study regards a sensitive topic for the companies as it touches upon strategic matters.

3.6.3 Generalizability

Generalizability means the extent to which the research findings can be extended to other cases or settings (Collis & Hussey; 2014). Since every company has its own environment, internal processes, investment possibilities and employees, the results cannot be fully generalized. However, the results can still be applied to companies in settings as the investigated companies in this study, meaning large incumbent manufacturing companies which can do heavy investments in a new technology and who operate in Sweden. Furthermore, the results can be generalized to other actors in the AM industry as well, as the interviews at all companies were conducted with an industrial perspective in mind.

3.7 Reflections concerning ethics

The conducted interviews were all treated anonymously, meaning that the names of the interviewees are not displayed. The purpose of this was to not limit the interviewees during the interviews and to provide an open atmosphere for discussions. However, the function of each interviewee is displayed in the report to increase the reliability of the study. Treating the interviews anonymously is also aligned with Vetenskapsrådet’s codex which states that “All information about identifiable persons should be noted, stored and reported in a way that individuals cannot be identified by externals. In particular, this applies to information that might be ethically sensitive. This implies that it should be practically impossible for externals to retrieve the information” (Vetenskapsrådet, n.d.). Lastly, as Collis and Hussey (2014) advices, all interviewees participated voluntarily, meaning that no financial compensation was offered.

Further, when writing the report, the aspect of plagiarism has been actively avoided. The literature review is primarily based on a number of peer reviewed articles and these have been properly referenced so that it is clear that the material originates from no one else than the true author.
This chapter is divided into three main categories: value proposition, value creation and value capture. Within these categories, the results from the interviews are firstly presented per university and per company. In the end of each subchapter, a summary of the findings is presented. The citations from interviews in Swedish have been translated to English.

4.1 Value proposition

Below, the empirics regarding the value proposition are presented. This includes the interviewees thoughts on AM offerings, target customers and position in the value chain. After each organization’s empirics are presented, a summary of the respective organization’s statements will follow. The summary is color coded with colors indicating the level of certitude and confidence of the answers; green equals a confident “yes”; yellow equals hesitation or doubtfulness, or that one company representative is sure of “yes” and the other one sure of “no”; red equals a confident “no”. The statements are presented in an alphabetical order in the summary.

4.1.1 Universities

The respondents are a Professor from University A and a Research Director from University B.

Regarding the demand for AM components, the Research Director sees the reduced time to market and the possibilities to reduce inventory for spare parts as two drivers. The Professor believes that the drivers of the demand for AM and the maturity of the demand varies. He gives the examples that in the medical industry, where AM is already relatively mature, there is a clear demand for customized products while in the automotive industry, the demand is for large-sized components – an area where AM has not yet reached maturity. To meet these demands, both the Research Director and the Professor says that building up an AM knowledge base is important; “This knowledge base will in the end be your competitive advantage as compared to those joining later.”

When building up knowledge, the Professor does not believe that companies must have a specific customer in mind. Instead, he believes that they should have an open mind and a broad focus when it comes to customers, in other words that companies
do not have to target specific customer segments. Instead, it is better to investigate what technology could serve as the main business:

“My suggestion is to, rather than looking what industry to work with, you should look at what technology base you should excel in.”

(Professor, 2018)

When approaching customers, the Research Director believes that it is necessary to have a mature solution in place. This since there is a risk that the customers also will be approached by sub-suppliers with developed offerings. On the other hand, the Professor believes that it is important for companies to be visible in the AM market as soon as possible to show customers that they exist. Entering the market should be done in parallel to developing a knowledge base and setting up the business. Also, the Professor states that for AM, it will not be possible for companies to develop offerings without involving customers. Further, the Professor believes that initially, customers will not ask AM companies to design components for them. They will instead bring basic designs and then the supplier can provide expert advice on how to alter the design to become optimal for AM. Still, he does not believe that companies must develop their own design bureaus to provide the expert advice.

The Professor continues with saying that an environment where customers can come and experiment with companies at a lower cost than setting up their own AM facility should be the aim, thus offering knowledge. The Professor believes that currently, customers will only set up their own AM facilities if they realize that AM is a game changer for them. Otherwise, they will choose any company as a service provider. Still, while AM evolve, many actors are still reluctant to invest and this is partly because of the uncertainty regarding the maturity (and the difference in maturity between different AM technologies). Therefore, the Professor believes that being a service provider is a good strategy – at least for now. However, in the future when AM technologies have become more mature and customers may be more open to changing their business models, he believes that more actors will investigate the possibility of setting up their own AM facilities. This since one of the biggest advantages with AM is that the supply chain has the potential of becoming highly compact. Further, the Professor says that even if the actual printing time is currently perceived as too long for many, the overall process time is still short and the long printing times can already now be tolerated if the whole value chain is considered:

“A lot of companies will come to you if you are a service provider because they do not want to develop their own in-house facilities and invest heavily internally until the technology has matured. [...] Say for example [a customer], they are interested in the technology but at the moment they are not really sure which way to go. What they will do, in order to stay on the train and keep experimenting, is to go to an AM company and say ‘can you do an experiment on this product?’.”

(Professor, 2018)
The Research Director believes that an increase in sub-suppliers focusing on providing services but not covering the whole value chain will be seen in the future. However, he states that providing an end-to-end solution is a brilliant idea if companies is capable of it and that it would then bring great advantages. Still, both the Professor and the Research Director states that being able to cover the value chain will be possible for some companies and challenging for others. The Professor believes that it in particular will be more difficult to cover the whole value chain for companies that do not have their own material production since “the starting cost will be very high”. Also, a problem when providing customers with end-to-end solutions is that it brings risks to large OEMs as they do not want to rely on only one supplier – something they would do if they had only one supplier for the full AM solution. Further, the Professor believes that not covering the whole value chain will not be a problem since it is best for companies to focus on the area, or areas, of the value chain where they have most competence:

“For a company that is planning to start from the scratch, for them looking at the whole chain will be much more challenging. Some companies are thinking of just doing post-processing for AM components and some to only focus on the printing process, having materials coming from the outside and post-processing being done by someone else.”

(Professor, 2018)

Another reason why the Professor is not convinced that companies must cover the whole value chain is because he believes that the design will still be done by the customers, as previously stated. However, even if a company does not cover the design part of the value chain, it should still have designer competence. The reason for this is that being able to provide expert opinions from an AM perspective will add a lot of value for customers even if they are making their own designs:

"You should be able to provide them an expert opinion, but maybe not covering the whole value chain, for example designing for them. Design will still happen at the companies who are the real designers of the final products. [...] Your customers might go back and rethink the design and then next time they might engage you, because you are part of their value chain.”

(Professor, 2018)

Further, the Professor believes that a safe AM strategy is to start with producing AM components for internal use since this enables companies to learn AM and identify the actual customer value, thereby motivating the case. It is also a way of ensuring having a business even if no one else is buying the services. He says that “in my opinion, this is the safest way that many of the companies want to take”. And a last statement to keep in mind regarding the offering is that, according to the Research Director, companies’ offerings should never compete with that of suppliers.

Figure 4.1 displays a summary of the value proposition findings from the universities:
4.1.2 Company A

The respondents are the CTO, the Operations Manager and the President from a spin-off organization within Company A.

Both the President and the Operations Manager of Company A have identified an increased demand in AM knowledge. The reason for this is that only a few companies have done comparable investments in AM as Company A and therefore, they approach Company A to learn how they can benefit from AM and if there is a smarter or cheaper way for them to produce certain components. Besides basic knowledge about AM, the CTO has identified a growing demand in spare parts and complex components produced with AM techniques. The Operations Manager agrees with this statement and further predicts that the complex components produced with AM will be using “simpler” materials. Thereby, the need for advanced materials for AM would be reduced.

Further, the Operations Manager and the CTO believes that it is highly important for all companies to provide end-to-end solutions to customers, but according to the CTO, only a few companies will be capable of it. At this stage, the CTO has seen few examples of it on the market. One of the reasons why it might be important to provide end-to-end solutions is that it is critical for the components produced by AM machines to be properly processed in the later stages of the value chain. This final stage, post-processing, is something that all interviewees bring up as something that the market yet has not understood the importance of and that it is something almost all AM components will require.
A potentially attractive offering that all interviewees mention is to develop process parameters, meaning that companies should be able to guide customers to the right combination of material, machine parameters and component design to meet customer requirements. However, design is something that the CTO does not see any scalability in. The same goes for prototypes; he believes that there will be margins on prototypes but that the low possibilities of scaling that up makes it questionable to base a business on it. The CTO is also skeptical towards the strategy of focusing only on the actual printing of AM components since he believes it is a stage that does not create much value and because it will be a competitive market. Therefore, he believes that serial production in a small scale is a more appropriate alternative.

All interviewees believe that building a solid AM knowledge base will strengthen a company’s offering. However, this process is costly and all companies needs to make its own analysis to see if such a process is worth the investment. The President adds that an offering based on deep knowledge will be difficult to copy as competitors would have to go through the same journey if they wanted to develop it themselves. The Operations Manager argues that while building a knowledge base, it is also important to show customers that you, as a company, “exist” and are focused on developing your knowledge base. All interviewees agree that a way of doing so is to start using AM internally before targeting external customers. The President says that:

“I think that if we can show that we have mastered these technologies and used them on our internal products, we will have a very appealing selling argument to external customers.”

(President, 2018)

The President also says that Company A has a lot of customers “knocking on its door” and the Operations Manager believes that as long as they have the time and resources, they will be able to pick and choose customer. He adds that basically all types of customers are welcome. The CTO prefers to target large component manufacturers but does not think that companies need to have a specific customer in mind when developing their offerings. This since he, from talking to many actors in the market, believes that the market will certainly be large enough for it to be beneficial to develop some general base offerings. The President has not thought too much about customer segmentation and believes that it is a good idea to have a broad technology focus. Further, he is certain that almost all manufacturing companies will have at least one area where AM will be applicable:

“Everyone has some sort of component or area where AM can be valuable. You can use AM for something; to do something in a better way. Of that I am convinced.”

(President, 2018)

Figure 4.2 displays a summary of the value proposition findings from Company A:
4.1.3 Company B

The respondents are the CEO and the Sales Manager at Company B.

The CEO of Company B sees great variation in the AM demand; some customers already having a clear direction and strategy while others are slowly approaching AM and demanding knowledge. The CEO says that a common driver for approaching AM is that companies have identified that their competitors are working with it and therefore start investigating it themselves to ensure not falling behind. The Sales Manager also sees a large variation in the demand and the maturity of the market. One thing he sees as a driver for many companies to start working with AM is the benefit of reduced lead times. However, he warns that many companies fail to see the limitations of AM; they only see the possibilities. He emphasizes that AM is only a new production method that should be added to the current portfolio of traditional manufacturing technologies. Still, he explains that when companies show cases where they have reduced their lead times by a factor ten, it becomes impossible for competitors not to start investigating AM themselves:

“A manager hearing this realizes that ‘if we do not learn AM but our competitors are, then they can make ten product generations while we make one – we cannot not investigate this.”

(Sales Manager, 2018)

Further, the CEO believes that services are a very important part of the AM offering since the technology is highly complex. One example he brings up is that some
machine manufacturers are selling materials and process parameters together with the machines – a business model which has turned out successful. According to the CEO, the process of qualifying a material for a specific printer requires a lot of resources in order to receive an acceptable quality of the output and few companies even have the right competencies to do it since the process is time consuming, requires specific competencies and is extremely costly. Thus, providing customers with end-to-end solutions including for example a machine and material makes AM more “plug and play” and makes it possible to expect a certain result. Related to this, the CEO also mentions that one of the benefits of AM which is often brought up is that it allows for local production at no (or low) extra cost, but adds that this statement is exaggerated. For example, it is often suggested that suppliers will place AM machines at customer’s production plants and use them to print spare parts for the customers by sending over component files. The idea is that when a customer then needs a spare part, it can be printed immediately. However, according to the CEO, AM is not there yet. And this since AM machines often require advanced calibration and the printed components generally require a workshop for advanced post-processing. Further, when setting up an AM production plant, the CEO explains that you need to know very specifically what it is that you want to print since that sets the requirements of necessary supporting equipment. Thus, the variation of spare parts which can be printed in a specific machine and related plant is limited.

The CEO continues by stating that it is important for companies to have a unique selling point for their offerings and that a good starting point for a company’s AM offering is its current core business. And while it is good for companies to have their core business as a starting point, the CEO also believes that when working with AM, an end-to-end approach is critical:

“We are talking a lot about the end-to-end approach. For AM to really work in the industry, you need to make sure at an early stage that you have a business case: ‘is it something we can do better? Can we increase the value for our customers? Can we make our offering better? How do we sell the product and qualify it? This is something we emphasize, to consider the whole value chain.’”

(CEO, 2018)

He also believes that if a company is capable of covering the whole value chain in-house, it should. If not, it is better to start in a niche and work with partners to still cover the value chain:

“Can you do it in-house, do it. But if you are a smaller actor; work smart, find your niche. Where in the value chain can you jack in your offering? Where is your offering and who should you work with to cover the value chain? Because regardless, you need to cover it.”

(CEO, 2018)

Then, depending on the company, the CEO believes that the niche will either expand to other areas or become even more narrow. The Sales Manager, on the other hand,
believes that it is best for all companies to work as niche actors, both regarding customer segmentation and offerings. However, he believes that it is still important for companies to have competences in the whole value chain but that this competence should be for a niche technology. And this since it takes “so much knowledge about the end customers’ processes needs and requirements” to become a strong candidate. According to the Sales Manager, small actors do not have any other choice than to niche themselves due to a lack of resources, and large actors are rarely capable of using all their broad competence in an ordered and efficient way. This would mean that niching is the best option for all. The Sales Manager therefore explains that the careful selection of customers will decide a company’s niche.

Further, the CEO believes that since the technology is still not mature, it might be best for companies to start with a basic offering. An example is to start with the most basic materials which are commonly used and qualified for AM and then, as the technology matures, material offerings can become increasingly complex. The CEO says that it is important for companies to identify a demand or “industrial relevance” for their offerings. For example, if the offering is too advanced for the current immature market, it can be hard for it to gain acceptance. The Sales Manager also considers the AM market to be immature and therefore believes that “know-how” on how to use AM efficiently will be a highly attractive offering:

“*It is a lot about software and know-how. Know-how on how to use AM efficiently. To help customers find the most low-hanging fruits and to manage their expectations. [...] So that companies do not spend a lot of time developing components which are not paying off.*”

(Sales Manager, 2018)

The Sales Manager believes that software will be a key for “know-how offerings”. Further, he also mentions that providing customers with process parameters would be a good offering since this process is highly complex, as previously also mentioned by the CEO. Both the Sales Manager and the CEO believe that materials suppliers will pursue this strategy in the future – that is, selling process parameters together with the actual material. The CEO also says that these process parameters should be something that companies would want to spread to as many as possible:

“*If you have a good ‘recipe’, you want it to reach as many as possible. Well, from a material supplier perspective, you almost want to give it away together with the material.*”

(CEO, 2018)

The Sales Manager believes that an attractive offering will be to “increase the probability for a successful printing process” and that this requires advanced knowledge about customers and their processes. He means that companies should sell “outcomes” instead of products and refers to a bearing manufacturer that is selling “reduced friction” as a good example of this.
Further, the Sales Manager believes that it is appropriate to work with external customers already at an early stage as a proof of concept; “if external customers are not willing to pay us, then there is something wrong with our offering”. Building on this, the CEO emphasizes that companies need to realize that AM is a production method with the potential of increasing the value provided to customers. Hence, it is important to develop an offering which customers are willing to pay for, otherwise they should do something else: “if no one wants to pay for it, it is just a hobby”.

Figure 4.3 displays a summary of the value proposition findings from Company B:

<table>
<thead>
<tr>
<th>WHAT IS THE CURRENT DEMAND?</th>
<th>WHAT SHOULD THE OFFERING BE?</th>
<th>WHERE TO OPERATE IN THE VALUE CHAIN?</th>
<th>WHO TO TARGET?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Basic offering in the beginning</td>
<td>End-to-end solution (with or without partners)</td>
<td>A careful selection of customers</td>
</tr>
<tr>
<td>Reduced lead times</td>
<td>End-to-end solutions</td>
<td>Niche in the value chain</td>
<td>External customers</td>
</tr>
<tr>
<td>Variations in demand</td>
<td>Knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Process parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sell &quot;outcomes&quot; instead of products</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Services</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Software</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Starting point in the company’s core business</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local production</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 4.3. Summary of findings from Company B related to value proposition.*

4.1.4 Company C

The respondents are a Board Member from the organization which Company C is a spin-off from, and the General Manager and the Sales Manager at Company C.

The Sales Manager has identified a demand for a broader range of AM materials. Further, he has also identified demands for more complex products and components with high surface finish and high resolutions. The Board Member agrees with this statement and adds that AM in that way enables producing components which otherwise would not have been possible to realize. The General Manager believe the demand is not yet mature but has also identified a demand for high surface finish, a high degree of details in AM components, fewer assembly steps, fine tolerances and increased productivity; however, it is something few actors currently master.
Even though there is a demand for increased productivity, it is still not possible for AM to compete with traditional manufacturing technologies regarding that aspect in high-volume production. This even though the Sales Manager and General Manager see that complex products are ready for serial production and not only prototyping. Still, AM can already now compete regarding functions and performance and the Board Member is convinced that more will happen in the future. The AM market is currently considered immature and for a market in this state, the Board Member believes it is good for companies to be able to guide customers throughout the whole value chain; to help customers increase productivity. He further argues that whether this is done in collaborations with partners or in-house does not matter. Instead, it depends on the costs and capabilities of the company. At the same time, companies need to be careful about partnerships downstream in the supply chain in a way that limit their own markets or compete with suppliers’ offerings. The General Manager, on the other hand, does not believe it is important to provide customers with end-to-end solutions. This since customers are designing their components themselves. Instead, companies should position themselves where it suits them in the value chain. An example is that companies can provide customers only with feedback on their designs, but a demand for doing the complete design for customers has not been seen, according to the General Manager and the Sales Manager.

According to the Board Member, it is important to always keep the company’s overall strategy in mind to make sure that AM initiatives do not expand into areas which are too far away from the company’s core business. The Board Member emphasizes that it is critical to enter the market and show customers that you exist; if a company waits until its’ competitors approach customers, it is not certain that the company will be able to supply the core AM business it had in mind: “Buy machines, put a few people to work on it, then teach the market how to use the to drive productivity.”

Further, according to the Sales Manager, not having defined what demand to meet before developing an offering can be risky unless the company has a lot of resources or does not rely entirely on that unidentified demand. However, defining a demand can be difficult as customer do not always know what they want. Therefore, companies should also envision the market and prepare with the help of indications:

“It is always good to know what customers actually want. Otherwise, you sit on your own and develop something for a long time and when you release it, the result will perhaps be that no one wants it. And then you are in trouble.”

(Sales Manager, 2018)

Regarding customer segmentation, the General Manager believes that it is the company’s choice of AM technologies and offering that decides the customer niche. However, the Sales Manager explains that customer segmentation has not been in focus for Company C simply because for them it does not matter in which industry their customers operate in as long as they are interested in the type of offering that
Company C provides. He adds that currently, there are only a few customers approaching Company C demanding AM knowledge; most customers already have clear cases. Company C has not experienced problems finding customers to try out its offerings, but it has taken time to scale up to the volume since they are working with products which they have never created before. Usually, the development time is 2-4 years, but this is in most cases due to the customer’s own development work.

“You can not produce this component [without an AM enabled solution]. It will cost more [with AM], but customers are prepared to pay. You just have to find the right components.”

(Sales Manager, 2018)

The General Manager believes that if a company is unsure of what it should be doing and believes that it is safer to start with internal AM cases, there is no reason not to do so. However, he explains that it does not matter if the customer is internal or external, it will still look poor if the company is unable to deliver or if it performs badly. On the other hand, the Board Member believes that working with internal cases (if the company has the possibility) is a good starting point. Then, when expanding to external customer, it is important to not start competing with the end-customers by becoming a producer of their products. More, he says that it is critical for companies to not engage in development projects with customers where the derived knowledge cannot be shared with others than that specific customer.

Figure 4.4 displays a summary of the value proposition findings from Company C:
4.1.5 Company D

The respondents are an Engineering Leader and an Engineering Manager at Company D.

Both the Engineering Manager and the Engineering Leader say that the current AM demand is not about AM products per se but rather about improved performance which can be enabled by AM. Thus, as long as the customers have their needs met, they are not interested in what technology enabled it or how the problem was solved. The Engineering Manager also says that Company D has a great drive and willingness to thoroughly understand the AM processes, but he believes that “normal” AM actors probably neither have the resources nor the drive to become as detailed as Company D when it comes to knowledge about AM. He also believes that in the cases where there is an actual demand for AM products and services, the demand is mainly centered around knowledge; he claims that many actors who are entering the AM market at this point need someone to “hold their hand”. For example, to develop process parameters, the process of matching an AM material to an AM machine and component, is highly complex and he believes that a good offering from material suppliers would be to support customers with these process parameters as well, not only providing the actual material. He even believes that the material suppliers which are not doing this in the future will have a hard time to survive, since it will be such an important part of the offering. Currently however, the machine manufacturers are the main actors providing process parameters for specific materials and machines, according to the Engineering Manager.

At Company D, AM is considered an enabler to provide customers with new and improved product functionalities. Thus, by equipping their current products with AM produced components, both the Engineering Manager and the Engineering Leader agree that AM can strengthen Company D’s offering significantly through the reduction of product sizes, prices and lead times – the Engineering Leader is hoping for a decrease from 20 weeks to 2 weeks for some components. However, they are not there yet. In the future, the Engineering Leader also hopes that they will be able to provide their customers with completely new functionalities enabled by AM and this is the great aim of Company D’s AM initiative:

“I believe that the biggest win will be when we start designing for AM so that we can solve problems and add functionalities which are not available today, which are not technically possible to do.”

(Engineering Leader, 2018)

Both the Engineering Manager and the Engineering Leader explain that Company D only has internal customers at the moment. However, the Engineering Leader says that they have started discussions on whether it would be good to move towards external customers as well. The Engineering Leader says that Company D is not stressed to approach an external market since they view AM as a complement to their current core offering, but one benefit that he identifies from working with
external customers is that it allows the sharing of development costs with other actors. However, this is not the focus of Company D’s operations today as their focus is rather on improving their own offerings with the help of AM technologies. Still, the Engineering Leader believes that in general, it is good for companies to start internally to build up some successful cases before approaching external customers. One reason for this is that it makes the external offerings more credible if they are backed up with internal use cases. However, in Company D’s case, he says that they will probably never offer all their internal solutions to the external market. For example, if Company D develops a component with completely unique properties, then they will not offer it to other actors, since that could instead work to give Company D a competitive advantage. On the other hand, if a newly developed component offers the same functions as the current solutions, only improved (for example through decreased weight), then it would be a potential offering to an external market.

Further, the Engineering Manager believes that for companies that are similar to Company D (but which are approaching external customers), it is smart to focus on a specific customer niche since many industries where AM is used have high barriers, for example the aerospace industry. The Engineering Leader agrees with this statement to some extent but is more hesitant. Still, he believes that a niche focus will be a natural choice for many companies since different industries have significantly differing demands, for example regarding certifications and traceability. However, he also says that if there would be a business opportunity to approach a broader range of customer segments, then that would be a good strategy as well.

The Engineering Leader believes that end-to-end solutions are of high importance since the different processes in the AM value chain are highly intertwined and involve a lot of IP. This is something that makes him nervous:

“I think this is especially important in a supply chain organization: there is a lot of IP in, for example, a CAD drawing which we already have today. But for AM, we also have another file for the production parameters: how to print; orientation parameters; how to post-process. And when mastering this, I would be extremely nervous that it would get into the wrong hands. That someone hacks the computer where I have all the information.”

(Engineering Leader, 2018)

However, despite the intertwined steps of the AM value chain, the Engineering Manager says that few companies can manage to cover the whole value chain themselves and that the companies which are actually capable of it are unique. The Engineering Leader further argues that if he could choose between a supplier that can deliver end-to-end solutions and another supplier that can supply parts of the value chain but where the rest of the value chain needs to be completed with other suppliers, he would always choose the end-to-end solutions supplier as long as the final result has the same quality. Still, this is not yet a situation which Company D
have to face since they, as stated previously, are solely working with AM in-house for internal use. The Engineering Leader mentions that companies also can cover the value chain together with external partners or through mergers and acquisitions.

Figure 4.5 displays a summary of the value proposition findings from Company D:

![Figure 4.5. Summary of findings from Company D related to value proposition.](image)

4.1.6 Company E

The respondents are the Group Manager and the CTO at Company E.

According to the CTO, customers are currently not demanding specific AM produced components. Instead, they demand functions, features or improvements in products which can be realized through AM. He further explains that AM allows Company E to become better and quicker and to take a more competitive position relative to competitors. Also, he says that AM enables the Company E to become more flexible and to increase customization of their offerings:

“We support customers in terms of requirements for productivity and efficiency improvements. That is what we do. But for them, it does not matter whether it is AM or another technology that enables it.”

(CTO, 2018)

The Group Manager calls AM “the revenge of the high-cost country”. He explains that traditionally, high-quality products have been designed in USA, Germany or Sweden but in the 80’s and 90’s, much of the manufacturing was exported to low-cost countries like Bangladesh and Vietnam. However, with AM, there is no reason to place the manufacturing at a remote location. This since the components can be printed at the same price “around the corner” and with salaries which are
insignificant in the context. This is one of the benefits with AM; how it allows for local production. He gives the example that Company E has component batches which are printed for 160 hours unmanned and without breaks. The operator is only involved during two hours in the beginning of the printing and two hours at the end. Thus, it does not matter if the operator’s salary is high or low since it becomes insignificant in the context. The Group Manager also mentions several other benefits with AM which are also common demands from customers, for example large reductions in lead- and development times, flexible design and reduced greenhouse gas emissions from production. However, he builds on the CTO’s argument that customers do not care which technology that in the end allows for their problems to be solved and explains that the actual demand for AM is minimal and that companies need to arise interest among potential customers themselves:

“Right now, there is no demand from the market at all. We are the ones trying to arise interest among our customers for AM. And we use AM as an example to prove our innovative abilities. But the market is not mature at all – especially not in Sweden. Sweden is a developing country when it comes to AM.”

(Group Manager, 2018)

Since there are few customers on the external market, the Group Manager believes that it is necessary for most companies to have both internal and external customers to utilize the full capacity of their AM investments. If they would focus solely on internal or external customers, they would simply not have enough business cases. According to the CTO, Company E currently works with both internal and external customers – thus, the company is both a user and a supplier of the AM technology. The Group Manager explains that Company E started with internal customers but that companies in general should take all chances they have to work with external customers, since the interest is so low. Further, the CTO explains that Company E’s customers mainly access their AM offerings through upgrades of previous offerings, in other words, upgrades in products they already buy (which are argued to improve the customer’s profitability). Thus, most of Company E’s external AM customers are current customers within other areas of Company E.

Adding on to customer segmentation, the Group Manager does not believe that companies should niche themselves towards a specific customer segment. The CTO also believes it is good to be open for a broad range of customers and not from the start define a clear target customer group for the offerings. However, at the current maturity of the market, the Group Manager underlines that reaching a broad customer range is a struggle for AM companies, simply because it is so hard to find customers. He explains that the lack of demand forces AM companies to start with specific customer segments since there are simply only a handful of different customer groups which are currently interested in AM:
“If there would be a broad range of customers, then there would have been a possibility to choose. But now, you do not have customers who are interested in AM. Instead, you need to be happy if you find one external customer. And if you do, you are probably so happy that you choose to spend a lot of time and effort on that customer. But yes, if you have the possibility to identify several customer segments – fine, do it! But that is probably not the reality. [...] It is very hard. There is no demand. If there would have been 30 large companies demanding AM, then there would have been a market. Now we have to create the market first. And this is something I have done internally since 2009, and it has been incredibly hard and embarrassing at times.”

(Group Manager, 2018)

The Group Manager explains that Company E has been working with AM from an early stage and in the beginning, they printed models of local buildings because they did not have any customers or demands, but still wanted to learn the technology. However, being only a print shop offering printing service of AM components is nothing he recommends since he is convinced that the printing will soon become a commodity. The CTO instead says that Company E have reached a stage where they consider AM as a tool to reinforce their capabilities. However, both the CTO and the Group Manager believe that AM is still not mature, and building on this, the Group Manager says that:

“I would say that the technology is fully mature for rapid prototyping – when you are using your own prototypes and when the worst thing that can happen is that your test rig or development facility is damaged. For this, you can use AM without any major problems. However, when you are selling to an external customer, and you might lose your reputation and your name, or become responsible for personal injuries or property damage – that is a completely different matter. [...] But yes, I can sell a prototype to an external customer if I know that the customer will only use it in a controlled environment, for example a test rig. But regarding commercial products, which would be put in trucks, cars, airplanes or gas turbines... people can get hurt. And there, I do not believe that the technology is mature yet.”

(Group Manager, 2018)

Further, both the CTO and the Group Manager believe that it is good for companies working with AM to be familiar with the whole value chain. The CTO explains that covering the whole value chain enables a quick feedback loop from iterations, something that will be attractive for customers. Further, he explains that even though it is important for customers that their AM suppliers cover the value chain, this is something that can be done through partnerships and collaborations. It is both difficult and costly to have all knowledge in-house, especially from the beginning. The Group Manager agrees with the statement that the customers want as few contact points as possible in the value chain, and that end-to-end solutions can make the customer experience more seamless. Thus, if companies have the possibility to act as one-stop-shops, then they definitely should. However, this should not be a “deal breaker”; even though a company cannot offer a solution covering the whole value chain, this should not prevent them from entering the AM market:
"You have to start somewhere. And if you do not make these mistakes, you will never reach a full solution. And I do not think that any actor in Sweden can go from not working with AM at all to becoming a one-stop-shop immediately. This is something that emerges gradually. You do not know what customers want before you have worked with them."

(Group Manager, 2018)

Both the Group Manager and the CTO believe that offering a solution to customers that covers the whole AM value chain will be an attractive offering. The CTO further mention that since the AM process is complex and the knowledge is generally limited, a good business model would be to provide customers with process parameters in addition to a machines or material in order to facilitate the process for customers. Identifying the process parameters required for reaching a certain quality is something that few will be capable of and thus, it will be an attractive offering.

Figure 4.6 displays a summary of the value proposition findings from Company E:

<table>
<thead>
<tr>
<th>VALUE PROPOSITION: Company E</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHAT IS THE CURRENT DEMAND?</td>
</tr>
<tr>
<td>Improved performance of current offerings</td>
</tr>
<tr>
<td>Low demand for AM per se</td>
</tr>
<tr>
<td>Local production</td>
</tr>
</tbody>
</table>

Figure 4.6. Summary of findings from Company E related to value proposition.

4.1.7 Company F

The respondents are a Business Developer and a Design Manager at Company F.

At Company F, AM is considered as a way of improving existing offerings and explore new business cases. Both from a Company F perspective and generally, the Design Manager believes that it is good to start by identifying the benefits of AM for internal purposes. He also believes that building an AM knowledge base is important. However, he is not sure if he sees certain offerings being considerably more attractive than others. However, he emphasizes that building up an internal knowledge base is especially important within industries where quality and performance demands are high. The Business Developer explains that Company F’s aim with AM is to reduce costs and improve the functionalities of its offerings. He believes that this is a good approach when working with AM and he says that AM can be used for both optimization of current offerings and in the development of new offerings.
Further, the Design Manager argues that companies do not need to cover the whole value chain – he sees that both alternatives (covering the value chain or focusing on a niche area) can work well. The Business Developer agrees with this statement; he does not believe that it is necessary for companies to cover the whole AM value chain. Instead, he says that AM is a manufacturing process like all others and argues that just as with traditional manufacturing technologies, there will be all different kinds of actors in the market. Thus, whether a company is focusing on a niche area within the value chain or covering the value chain will not determine the company’s success.

Regarding customer segmentation, the Design Manager believes that it is better to target a niche than to have a broad focus. The Business Developer, on the other hand, believes that it is impossible to give a general answer on whether companies should focus on a niche customer segment or have a broad approach. However, he says that it is probably a good start to approach customers who have come further in their acceptance for AM instead of targeting the most conservative customers first.

Figure 4.7 displays a summary of the value proposition findings from Company F:

<table>
<thead>
<tr>
<th>WHAT IS THE CURRENT DEMAND?</th>
<th>WHAT SHOULD THE OFFERING BE?</th>
<th>WHERE TO OPERATE IN THE VALUE CHAIN?</th>
<th>WHO TO TARGET?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved performance of current offerings</td>
<td>End-to-end solution (with or without partners)</td>
<td>Internal customers (good starting point)</td>
<td>Niche segments</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Niche in the value chain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New functionalities</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Figure 4.7. Summary of findings from Company F related to value proposition.](image)

4.1.8 Summary of value proposition empirics

In table 4.1, all companies’ and the universities’ statements regarding the value proposition are presented in the form of a business model framework developed by the authors. The answers are not describing the company’s own business models, thus they do not for example describe what the company in question is offering but instead what the interviewees believe is a generally good offering for AM companies. The colors in the table indicate the certainty of the answers; **green (G)** equals a confident “yes”; **yellow (Y)** equals hesitation or doubtfulness, or that one company representative is sure of “yes” and the other one sure of “no”; **red (R)** equals a confident “no”. The answers are presented in an alphabetical order, thus the order in which the findings are presented has not been valued by the authors as having higher or lower importance.
### Table 4.1. Summary of findings related to the value proposition.

<table>
<thead>
<tr>
<th>SUMMARY OF FINDINGS: VALUE PROPOSITION</th>
<th>Universities</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
<th>Company E</th>
<th>Company F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DEMAND</strong></td>
<td></td>
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<tr>
<td>Broader range of AM materials</td>
<td>G</td>
<td>G</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Complex structures</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
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<td>Customized products</td>
<td>G</td>
<td>G</td>
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<td></td>
<td>G</td>
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<tr>
<td>Fewer assembly steps</td>
<td>G</td>
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<tr>
<td>Fine tolerances</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td>Full design solutions</td>
<td>R</td>
<td>R</td>
<td></td>
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<tr>
<td>High degree of detail</td>
<td>G</td>
<td>G</td>
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<td>High surface finish</td>
<td>G</td>
<td>G</td>
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<tr>
<td>Higher productivity</td>
<td>G</td>
<td>G</td>
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<tr>
<td>Improved performance of current offerings</td>
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<td>G</td>
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<tr>
<td>Knowledge</td>
<td>G</td>
<td>G</td>
<td>Y</td>
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<tr>
<td>Large-sized AM components</td>
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<tr>
<td>Low demand for AM per se</td>
<td>G</td>
<td>G</td>
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<tr>
<td>New components</td>
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<tr>
<td>Reduced inventory</td>
<td>G</td>
<td></td>
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<tr>
<td>Reduced lead-times/time to market</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td>Spare parts</td>
<td>G</td>
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<tr>
<td>Variations in demand</td>
<td>G</td>
<td>G</td>
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</tr>
<tr>
<td><strong>OFFERING</strong></td>
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<tr>
<td>Basic offering to start with</td>
<td>G</td>
<td>G</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Complex materials</td>
<td>Y</td>
<td>G</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>End-to-end solutions</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
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</tr>
<tr>
<td>Full design solution</td>
<td>R</td>
<td>R</td>
<td></td>
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<tr>
<td>Help customers increase productivity</td>
<td>G</td>
<td></td>
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<tr>
<td>Improved performance of current offerings</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
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<td></td>
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<tr>
<td>Internal use cases as proof of concept</td>
<td>G</td>
<td>G</td>
<td>Y</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Knowledge</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td>Local production</td>
<td>Y</td>
<td></td>
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</tr>
<tr>
<td>Mature/full solution when approaching customers</td>
<td>Y</td>
<td></td>
<td>Y</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>New functionalities</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Offering that competes with downstream actors</td>
<td>R</td>
<td>R</td>
<td></td>
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<td></td>
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<tr>
<td>Only printing service</td>
<td>R</td>
<td></td>
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<tr>
<td>Post-processing</td>
<td>G</td>
<td></td>
<td></td>
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<tr>
<td>Process parameters</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td>Prototypes</td>
<td>Y</td>
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<tr>
<td>Sell &quot;outcomes&quot; instead of products</td>
<td>G</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Services</td>
<td>G</td>
<td></td>
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<tr>
<td>Software</td>
<td>G</td>
<td></td>
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<tr>
<td>Starting point in the company’s core business</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td>Unique internally developed solutions to an external market</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td><strong>VALUE CHAIN</strong></td>
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</tr>
<tr>
<td>End-to-end solution (except full design solution)</td>
<td>G</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End-to-end solution (with or without partners)</td>
<td>G</td>
<td>Y</td>
<td>Y</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Focus on the areas where the company has its core capabilities</td>
<td>G</td>
<td></td>
<td></td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Niche in the value chain</td>
<td>Y</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td><strong>CUSTOMERS</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>A careful selection of customers</td>
<td>G</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Broad customer focus</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Choice of technology decides customer niche</td>
<td>G</td>
<td></td>
<td></td>
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<tr>
<td>External customers</td>
<td>G</td>
<td>G</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Internal customers (good starting point)</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Large manufacturers</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Niche segments</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open mind and broad focus when targeting customers</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2 Value creation

Below, the empirics regarding value creation are presented. This includes the interviewees thoughts on internal challenges, core assets and capabilities along with desired collaborations. After each organization’s empirics are presented, a summary of the respective organization’s statements will follow. The summary is color coded with colors indicating the level of certitude and confidence of the answers; green equals a confident “yes”; yellow equals hesitation or doubtfulness, or that one company representative is sure of “yes” and the other one sure of “no”; red equals a confident “no”. The statements are presented in an alphabetical order in the summary.

4.2.1 Universities

The respondents are the Professor from University A and the Research Director at University B.

According to the Research Director, besides the many advantages associated with AM there are also several disadvantages and challenges. These include high costs, limitations in component sizes, serial production and the development of AM competence. Due to these constraints, it is considered important to speed up the AM evolution. The Professor believes that collaborations will be a key to enable this, in the same way as when other technological evolutions take place:

“If you ask me, collaboration is the key to all these new developments taking speed. [...] In my opinion, collaboration is a must, particularly when the technologies are in the face of their maturity, heading towards maturity.”

(Professor, 2018)

Even though collaborations will be important, the Research Director sees that companies are not so willing to discuss their strategies and operations openly, leading to difficulties in having open collaborations. However, he is certain that openness would benefit all actors. Adding to this, similar to what the Professor says, he believes that it is important to create a critical mass for the development:

“In all technologies, when you work together, you multiply forces. Everyone can make money on that. If you have an end-customer who understands how AM works, and sub-suppliers who can supply products based on the requirements of the company, it makes the market grow much faster.”

(Research Director, 2018)

More, the Professor believes that it is already now becoming clear which of the AM technologies that are moving towards becoming mainstream and explains that some almost have gained a status of maturity. On the other hand, the Research Director says that several AM technologies are in place and are being used in manufacturing but still, he does not believe that the technologies fully have matured.
The Professor believes that possessing a large knowledge base will bring a competitive advantage to companies. And to be able to build that, the Professor believes that it is good to invest in AM machines and processes. The Research Director emphasizes that building a knowledge base is an extensive process which requires investments in machines and in understanding how different materials and processes work with different machines. A problem companies will encounter regarding this, according to both interviewees, is the great challenge of finding the right competence. For this, universities have an important role to play since students currently only get a basic introduction to AM. Further, according to the Research Director, it is also important for companies to educate employees in order to increase both the acceptance and the knowledge on AM if they want to push AM into industrial applications.

Further, the Professor states that companies could either have a broad focus or niche themselves to certain technologies; the choice depends on each company’s strategy and where it has its core capabilities. This since it can be too much of a challenge for many companies to have a too broad scope. Further, regarding the different AM technologies, the Research Director is also under the impression that having a broad focus or working with a niche technology depends on the company. At one point during the interview, the Research Directors says that companies providing materials should try to learn several technologies. At a later stage during the interview, he adds that large OEMs should learn several technologies as well, but that it is generally good for companies to niche regarding technologies and materials in order to provide customized solutions. The different AM technologies differ significantly and it might be difficult to master them all. The Professor states that providers of AM products or services should strive to engage with customers in the development of their products, often through an iterative process.

Figure 4.8 displays a summary of the value creation findings from the universities:

<table>
<thead>
<tr>
<th>VALUE CREATION: Universities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THOUGHTS ON CORE ASSETS?</strong></td>
</tr>
<tr>
<td>Invest in machines to learn AM</td>
</tr>
<tr>
<td><strong>THOUGHTS ON CORE CAPABILITIES?</strong></td>
</tr>
<tr>
<td>Broad or niche technology focus depend on capabilities/ambition</td>
</tr>
<tr>
<td>Educate workforce</td>
</tr>
<tr>
<td><strong>THOUGHTS ON PARTNERSHIPS AND COLLABORATIONS?</strong></td>
</tr>
<tr>
<td>Important to create critical mass</td>
</tr>
<tr>
<td>Important with collaborations to drive the market forward</td>
</tr>
<tr>
<td><strong>WHERE TO IMPROVE?</strong></td>
</tr>
<tr>
<td>AM competence</td>
</tr>
<tr>
<td>Component size</td>
</tr>
<tr>
<td>Costs</td>
</tr>
<tr>
<td>Serial production</td>
</tr>
</tbody>
</table>

*Figure 4.8. Summary of findings from the universities related to value creation.*
4.2.2 Company A

The respondents are the CTO, the Operations Manager and the President from a spin-off organization within Company A.

The Operations Manager believes that companies should not only work with one AM technology but investigate several; for example, evaluate which technologies that would support a company’s internal products or core business, and limit the focus only when the process get too slowed down. Further, the Operation Manager argues that companies should be careful with locking their strategies since the market still is immature. He also believes that it is important to not hesitate too long before entering the AM market. Instead, it is better to learn from an “AM journey” and find new niches to enter. He also believes that it is reasonable for companies to invest in machines to develop processes and to learn about AM. This since he does not believe that current machines will become outdated in the coming years. Further, he says that investing in machines is probably a better option than leasing if the aim is to learn the technology. When investing in machines, it is possible to modify them instead of having to return them in a certain state. The CTO also believes it is reasonable for companies to invest in different machines in order to build up knowledge about the printing process, something he believe is important.

The Operations Manager sees collaborations as a better way for companies to position themselves while the market is emerging, as compared to do everything in-house. However, he also states that such collaborations will have different characteristics depending on the company’s strategy and time horizon. Both he and the President argue that partnerships can be of the character of doing development projects together and aim at covering the value chain together with others (by covering different parts of it). Networks and partnerships are something that the Operations Manager believes is happening around other parts of Company A as well in terms of acquisitions and complete integrations into the organization. However, the Operations Manager believes that the current dynamic AM environment requires new ways of thinking regarding positioning and partnerships. It does not have to be about acquisitions but rather about alliances. The Operations Manager says that:

“It will be like a spider web where it will be different relations with customers, partners and suppliers. And all of these relations will build up our offerings and strengthen our business.”

(Operations Manager, 2018)

The President also believes that to enter “hyped” AM markets, it can be especially good to partner with actors who already has come a long way in that market. This since “getting a piece of the cookie is better than getting nothing at all”. As an example of a network, both the CTO and the President sees small and large print shops as future partners, but the President is not convinced that these will be very profitable unless they produce very high volumes.
The Operations Manager believes that Company A is in a good place regarding its internal assets and capabilities. At the same time, they are investigating what more they will need in order to solve arising challenges such as being able to analyze, and in other ways use, the data that arise from its AM processes and other challenges connected to digitization. Further, the CTO believes it is important to work in a structured way internally and ensure proper documentation of all knowledge that companies are building up. Adding to this, the President states that building up Company A’s base processes is something they are currently focusing on:

“We need to do some risky investments, bring in more people and machines to expand our capacity and to have a certain base to stand on.”

(President, 2018)

Figure 4.9 displays a summary of the value creation findings from Company A:

<table>
<thead>
<tr>
<th>THOUGHTS ON CORE ASSETS?</th>
<th>THOUGHTS ON CORE CAPABILITIES?</th>
<th>THOUGHTS ON PARTNERSHIPS AND COLLABORATIONS?</th>
<th>WHERE TO IMPROVE?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invest in machines to learn AM</td>
<td>Broad technology focus</td>
<td>A spider web with customers, partners and suppliers</td>
<td></td>
</tr>
<tr>
<td>Lease machines</td>
<td>Data analysis capabilities</td>
<td>A way to access ‘hyped’ markets</td>
<td></td>
</tr>
<tr>
<td>Structure internal processes</td>
<td>Important with collaborations to drive the market forward</td>
<td>New approach towards partnerships is required</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partnerships to cover the value chain</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.9. Summary of findings from Company A related to value creation.

4.2.3 Company B

The respondents are the CEO and the Sales Manager at Company B. The CEO believes that in order to learn an AM technology, companies need to work with it in practice. Not doing that would be like “having a restaurant without a kitchen”. However, he considers that buying machines to learn AM is too much of risk considering the rapid development and current immaturity of the technologies. Instead, he believes that leasing machines is the best strategy at the moment. He says that buying a machine makes it a part of the business until it has been depreciated while leasing offers full flexibility, and he says that “if there is a better technology on the market in two years, then that will be what we should work with and focus on”. The Sales Manager also believes that the risk of buying machines is too large for the maturity level where AM is today; he says that from what he has seen, there is a “gigantic immaturity” even in the best machines. In general, he believes that the
machines need to become better for AM to become an attractive option to traditional manufacturing technologies and he does not believe that companies need to buy or lease machines at this stage. Still, the CEO emphasizes that it is already now important to “stop talking and start testing AM”:

“You need to get your products out there and test them. We are now in the phase where we need to start manufacturing and stop talking: manufacture, test, see if it works – not just having more meetings to discuss whether to try it or not. [...] This is a mental barrier that you need to cross.”

(CEO, 2018)

Building a knowledge base with process parameters is something the CEO sees as a key success factor. Further, the CEO and the Sales Manager both believe that all companies should niche themselves in technology. The CEO says that companies must make priorities and then, depending on the strategy, it can expand into other areas or niche even more. However, at another time during the interview, the CEO says that he does not believe that it will be beneficial for companies to focus on a niche technology. He then argues that it is good to have a relatively broad understanding of AM to become an attractive partner. On the other hand, he says that just having knowledge about the three main machine brands will cover a large spectrum of the current market and he argues that this is enough for most actors. He also explains that he cannot see that any technology covers all needs and thus, he sees no convergence towards a specific technology. Still, the CEO believes that it is easiest for companies to focus on one technology to start with: “I believe that the key to be able to move to another island is to become really good at one thing first”.

Further, the CEO says that he is satisfied with Company B’s competence but explains that it will evolve in the near future. He further states that there is a general lack of AM competence in Sweden. In other words, it is hard to find skilled people. The Sales Manager agrees with this statement and he also believes that one of the most important actions companies can take in order to succeed with their AM initiatives is to work actively with education at all levels. Another common challenge identified by the Sales Manager is that many companies struggle with the “new thinking” that is required to reap the benefits of AM:

“[The CEO of one of Sweden’s most prominent AM companies] told me that their challenge today is to change the mindset of their designers, who used to build one prototype in two years. Because you know that the lead time is so long and if you make a mistake, then it will cost so much money, so you do not dare to take any risks. So this manager tries to get his designers to rethink. Because with AM, you can get a new component within days. And then it is suddenly OK to make mistakes. But this is a cultural matter – you need to change something fundamental.”

(Sales Manager, 2018)

Besides this, both the CEO and the Sales Manager have identified several other areas where AM needs to improve to become a more widely accepted option to traditional
technologies; and the main improvements regard the machines. The CEO also states that AM development projects within companies are often too slow and that the material price needs to be reduced. The Sales Manager, on the other hand, does not see the current material price as an issue. He argues that it is still a small part of the total cost for the overall AM process. Instead, he stresses that the material quality needs to be improved and explains that today, the same material from the same supplier can differ between batches, which in unacceptable for industrial companies.

Further, the CEO and the Sales Manager both believe that it is important with partnerships and collaborations to drive the AM market forward. The CEO states that the partnerships which Company B are involved in is their biggest success factor. He also states that Company B is open to collaborations and have such with several other AM actors. Still, he emphasizes the importance of understanding that partnerships are always about both giving and taking. More, the Sales Managers believes that a critical mass is extremely important for AM’s development in Sweden. He also stresses the importance of collaborations between the industry and universities, saying that “if we would just sit in the same room, we would solve the problems”. Lastly, he says that Sweden should learn from institutes in Germany where each institute has a different focus but they still collaborate to drive the development forward:

“In Sweden, we do not work to create a critical mass. We spread out initiatives. Our entire country is the size of a small town in China and still, we have more than 20 universities competing to profile themselves and receive separate funding. Instead, we must join forces!”

(Sales Manager, 2018)

Figure 4.10 displays a summary of the value creation findings from Company B:

<table>
<thead>
<tr>
<th>THOUGHTS ON CORE ASSETS?</th>
<th>THOUGHTS ON CORE CAPABILITIES?</th>
<th>THOUGHTS ON PARTNERSHIPS AND COLLABORATIONS?</th>
<th>WHERE TO IMPROVE?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lease machines</td>
<td>Educate workforce</td>
<td>Important to create a critical mass</td>
<td>AM project development times</td>
</tr>
<tr>
<td>Invest in machines to learn AM</td>
<td>Start in a technology niche</td>
<td>Important with collaborations to drive the market forward</td>
<td>Designer mindset and approach</td>
</tr>
<tr>
<td>“Stop talking and start testing”</td>
<td>The technology is immature</td>
<td>Broad technology focus</td>
<td>Machine maturity</td>
</tr>
<tr>
<td>Work with the technology to learn it</td>
<td></td>
<td></td>
<td>Powder quality</td>
</tr>
</tbody>
</table>

*Figure 4.10. Summary of findings from Company B related to value creation.*
4.2.4 Company C

The respondents are a Board Member from the organization which Company C is a spin-off from, and the General Manager and the Sales Manager at Company C.

For companies producing several highly complex products, investments in machines will quickly pay off according to both the Board Member and the Sales Manager. The Board Member believes that some AM technologies have reached a sufficient maturity level to meet the demands they have identified, and the General Manager believes that AM technologies are on a level of 6-7 on the technology readiness scale where 9 stands for fully established production. Therefore, they both argue that it is suitable for companies to invest in machines to learn about AM:

“Without a doubt [companies should invest in machines to learn AM]. Yes, absolutely.”

(General Manager, 2018)

The Board Member believes that building AM competences can enable companies to help customers with increased productivity through the use of AM. He further adds that when investing in machines and gaining AM knowledge, it is good to start within a niche technology and then expand into other technologies. The General Manager believes that whether companies should have a broad or narrow technology focus depends on its strategy, ambition and resources.

Company C leverage on the knowledge and resources within its owning company and the General Manager explains that they work closely together. However, when introducing new technologies like AM, it can pose internal problems. Company C has, for example, experienced problems with educating designers to approach AM and to change their mindset from not only focusing on traditional manufacturing technologies. Since the AM market is immature and changeable, the General Manager believes that companies must be able to revise their strategies after a while. He has heard from other actors that they have believed that their offering was suitable for a segment of the market but that it later turned out that that market was actually significantly smaller or bigger than they anticipated. Therefore, companies must go out to the market and try their offerings. However, since it is an expensive technology, it is still important to think through what position to take in the market.

Further, Company C believes that collaborations with universities, institutions and other companies are important to drive the AM market forward, according to the Sales Manager and the General Manager. Companies can for example partner with other actors to complement their value chain or to enter high barrier markets. The Board Member argues that such collaborations and development projects with customers are desirable as long as they do not limit the company with regards to which customers they can work with, meaning to get limited in helping other customers by not being allowed to share learnings. He also adds that companies need
to be careful about partnerships downstream in the supply chain in a way that limit their own markets (by taking over steps further down in the supply chain and thereby start competing with customers). According to the General Manager, partnerships in itself is nothing to aim for – they are only desirable if they offer win-win situations.

Figure 4.11 displays a summary of the value creation findings from Company C:

<table>
<thead>
<tr>
<th>VALUE CREATION: Company C</th>
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</thead>
<tbody>
<tr>
<td><strong>THOUGHTS ON CORE ASSETS?</strong></td>
</tr>
<tr>
<td>Invest in machines to learn AM</td>
</tr>
<tr>
<td>Broad or niche technology focus depend on capabilities/ambition</td>
</tr>
<tr>
<td>Leverage on internal knowledge</td>
</tr>
<tr>
<td>Start in a technology niche, then expand</td>
</tr>
</tbody>
</table>

*Figure 4.11. Summary of findings from Company C related to value creation.*

4.2.5 Company D

The respondents are an Engineering Leader and an Engineering Manager at Company D.

The Engineering Manager believes that it is better to focus on a technology niche rather than to have a broad focus. However, he argues that this depends on the size of the company; for example, Company D’s own AM initiative involves working with a broad range of materials and machines. Still, the Engineering Manager believes that this is a strategy which few companies can pursue. He also states that Company D’s strategy probably would be different if they approached an external market; then he believes that it would be better to focus on a specific technology or material. The Engineering Leader, on the other hand, believes that companies need to continuously investigate different technologies since new actors are constantly entering and the development is fast. He believes much will happen within materials and equipment in the near future and predicts a rapid development of the AM automation degree and hybrid technologies. Therefore, he believes that Company D needs to have many technologies on its radar – “the best technology today might not be the best technology in the future”. The Engineering Manager agrees with this statement:

“We have a broad focus because it is a very rapid development in this area, so you cannot say now that ‘this is the best printer and it will be the best one forever’. [...] And it will continue to be a rapid development. So we will probably need to exchange the printers continuously and it will be like this for quite a long time.”

(Engineering Manager, 2018)
Still, both the Engineering Manager and the Engineering Leader believe that companies should buy machines to learn AM since it is important to build practical knowledge. This even though the machines might be outdated in a few years. The Engineering Leader argues that it is important for companies to have the courage to invest because otherwise they might “miss the train”. Also, he stresses that there already are enough successful cases and positive indicators available to support investment decisions and draws a parallel between AM machines and computers:

“Of course, if I wait until next year I will have the chance to get a better computer than today, but on the other hand, if I need a computer today, I should probably make that investment today.”

(Engineering Leader, 2018)

The Engineering Leader also believes that investments are necessary in order for AM initiatives to truly succeed. Another argument he brings up regarding why companies should invest in AM machines today instead of hesitating and waiting for them to fully mature, is that if you wait, you will fall hopelessly behind:

“What we are doing here and now is to learn from our mistakes. This knowledge takes a lot of time, several years, to build up; what works and what does not work, how to design… You cannot become good at that by reading about it. And the ones who master it will have an extreme competitive advantage.”

(Engineering Leader, 2018)

He claims that it is a poor strategy to just work on ideas for AM instead of actually moving on to start working with the technology in practice. Ideas “will just be paper constructions” with no real value.

Further, the Engineering Leader talks about challenges regarding the AM process. He sees it as a huge challenge for designers to change their mindset but is convinced that it is best to start with the design to succeed. Designing for AM requires a focus on the optimal solution rather than to consider limitations in the production process:

“If you want to make really big progress within AM, then you need to start with the design. Surprisingly, it is the supply chain-side that has driven AM for several years but we believe that it must start with the design for it to really fly. [...] The general problem is, and this goes also for the design, that you must start thinking in a different way. Not focus on the technical issues but rather on the problem you want to solve. It is very hard to think completely new and it is easy to get stuck in traditional ways of thinking. That has been one of the challenges – to think completely unconditionally. You very easily get stuck in the ideas of the traditional products instead of thinking about the actual problems.”

(Engineering Leader, 2018)

The Engineering Manager also stresses the intertwined processes that characterizes the AM value chain. This is something which makes AM different from traditional
manufacturing technologies and which also poses challenges regarding internal capabilities; when using traditional technologies, the designer of a component can make a drawing and send it to a factory and trust that the factory handles the rest of the process. In the case of the AM process, the printing “recipe” is a part of the actual component and this means that the designers need to be involved in a larger part of the process and help to develop the recipe for the printing, not only the design. Thus, the Engineering Manager stresses that AM is more complicated than just pressing the printing button, especially for metal printing.

Apart from the challenge of transforming the way of thinking and working when designing and producing AM components, both the Engineering Manager and the Engineering Leader have identified the degree of automation as an area of improvement within the AM value chain. Currently, a lot of manual work is required in the process. Further, the Engineering Leader says that there is also a need for improved post-processing for AM. Apart from these areas, the Engineering Leader also believes that partnerships and collaborations with other companies and universities are important to drive the market forward. He especially believes that this is important for material suppliers, in order for them to create value for customers. Building on this, the Engineering Manager mentions that a collaboration which will probably be common in the future is the one between material suppliers and machine manufacturers.

Further, the Engineering Leader argues that it is often not cost effective for any company to do everything in-house and therefore, Company D will probably have a mix of internal development and development projects and collaborations with external partners. This is something they currently do within traditional technology areas. On the other hand, the Engineering Manager says that if a company is capable of handling everything in-house, then that is a better strategy since it gives a larger share of the return. Further, he explains that Company D has some collaborations but that he does not believe in complete openness (for example, at Company D, they keep their process parameters to themselves). The Engineering Leader mentions that Company D has partnerships and collaborations with other actors, both universities and companies, but not with any direct competitors, and he only sees benefits with this. Also, he says that since the AM technologies are still developing, it is hard to know what will happen in the future and that is another reason to be open for partnerships and collaborations. The Engineering Manager further explains that Company D has close collaborations with other internal units who are also working with AM; the separate units have different focus and they try to teach each other as much as they can. However, the Engineering Manager stresses:

“It is not like we buy and spread out AM machines everywhere, in all R&D departments. AM is too complex for that. You need to gather the competence.”

(Engineering Manager, 2018)
Figure 4.12 displays a summary of the value creation findings from Company D:

<table>
<thead>
<tr>
<th>VALUE CREATION: Company D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THOUGHTS ON CORE ASSETS?</strong></td>
</tr>
<tr>
<td>Invest in machines to learn AM</td>
</tr>
<tr>
<td>Gather competence</td>
</tr>
<tr>
<td>Important to regularly investigate new technologies</td>
</tr>
<tr>
<td>Work with the technology to learn it</td>
</tr>
</tbody>
</table>

*Figure 4.12. Summary of findings from Company D related to value creation.*

4.2.6 Company E

*The respondents are the Group Manager and the CTO at Company E.*

The Group Manager explains that Sweden is a developing country when it comes to AM. He says that other countries, for example Germany, England and France are at a much more advanced level. Further, he says that he still does not understand how a country with such advanced export as Sweden can be so far behind and that apart from Company E, he knows around five companies in Sweden working actively with metal AM. Thus, the market is “embryonic and not developed at all”. He also says that Company E was one of the earliest adopters of AM in Sweden and they wanted to use AM to prove Company E’s innovative abilities. However, for several years they experienced internal problems in getting their designers to understand the benefits of the technology. The CTO explains that changing the mindset of the designers is a common problem for companies working with AM and this is something that needs to change to reap the benefits that the technology can offer. Still, the CTO sees a rapid development within AM. He says that eight years ago, there were only some people talking about metal AM but now everyone wants to enter the market. However, few companies understand the complexity and challenges of it. Therefore, he believes that it is important to have a “proper approach”, which he believes is to have the available technology as a starting point instead of the materials. This since the final material property is not only dependent on the material but on a composition between the material and the other process parameters. He explains that at Company E, they used the components that they wanted to manufacture as a starting point and then defined and developed the material to be used in the process. In this way, the profile of the components allowed them to minimize the scope for material development and thus, they did not need to go through the entire spectrum of material properties. This further allowed them to minimize costs and achieve a quicker development process.
Both the CTO and the Group Manager further explain that Company E started within a technology niche but that they currently are expanding to other areas. The Group Manager believes that this is the only option for most companies; to become good at one thing first. Also, every new machine type requires new and costly certifications and qualifications which makes it hard for most companies to have a too broad scope from the start. However, he does not think that companies should limit themselves to only one niche technology in the long run, and he believes that after learning one technology, the step to learn the next one is not as big. The CTO says that for larger companies working with complicated products, it is important to learn several technologies. His strong opinion is that it is important to use different technologies and see how they can be utilized for different components. Further, he says that the market is constantly “booming” with new technologies and therefore, it is important for companies to stay updated and to continuously scan the market for new alternatives.

The Group Manager believes that the only reasonable thing to do is to invest in AM machines to learn AM. He argues that working with the technologies in practice is the only way to truly mastering them. And this even though the machines have not reached full maturity:

“Of course you need to invest in the technology. The way I see it, if you want to be an active actor in the market, you have no other choice. You need to master the successes and the problems. You need to be able to explain to the customer what to do when problems occur. And you can only do that if you have your own machine. You cannot learn this by reading in a book, you need to ‘live’ the manufacturing. You need to discover the problems yourself.”

(Group Manager, 2018)

The Group Manager draws the parallel to the early computers: if the early computer technology would have been dismissed because of its limitations, then artificial intelligence and augmented reality would never have been developed. Therefore, he explains, you need to “live the journey” and not fear setbacks – that is what you learn from. The CTO also believes that it is important for companies to work with the technologies to learn them and he agrees with the statement that AM machines can be compared to computers. However, he believes that an option for companies that do not want to make the investments due to the high costs is to lease the machines through collaborations with machines manufacturers. He argues that this would be away to avoid the risks of investing while still getting to work with the technology in practice.

Further, the Group Manager explains that at Company E, they are fascinated by how good the geometric repetitiveness of the AM technology is but that there are other problems which must be solved before AM will reach maturity; both the Group Manager and the CTO have identified several areas of improvement within AM. The Group Manager says that there is a general lack of competence in AM and that both
the software and hardware needs to be improved. At the moment, the software is “standalone”, meaning that data needs to be imported and exported between different programs during the process. This in turn means that quality is lost in each step and it is also problematic since companies need licenses for many different software which increases costs. However, he believes that this is something that will change in the near future since more and more actors are entering the AM market.

Regarding the machines, the Group Manager says that it is natural that they are not yet comparable to the standard of traditional technologies since AM is such a young and immature technology. Further, the Group Manager says that the material knowledge is low and that there are few standards. The CTO agrees with this statement and says that rapid development of standards is necessary and that the material price need to be reduced, something that will probably happen as more material suppliers enter the market:

One if the critical points is the number of material suppliers. [The material] is a significant contributor to the cost and if [the market] becomes more competitive, the prices will go down.

(CTO, 2018)

Lastly, the Group Manager says that there are unclear standards regarding health and security and this is an area which is critical to improve. This problem is also connected to the fact that the AM technology is so immature that directions and standards might not yet have been updated accordingly. And in turn, this forces managers to use their “common sense” when judging the risks of AM. However, despite the identified problems, the Group Manager refers to Gartner’s hype cycle and say that Company E has passed the “Trough of disillusionment”, where they have identified all the problems with AM, and that they are now working their way up the “Slope of enlightenment”, thus trying to solve the problems which have been identified in earlier stages of the cycle.

To drive the market forward, both the Group Manager and the CTO believe that partnerships are important – the Group Manager even says that it is the only option for Swedish companies to become competitive. The CTO further states that due to the complexity and high development costs which characterizes AM, it is important to have collaborations, especially in industries with high barriers to entry, for example in aerospace. Both the Group Manager and the CTO say that it is difficult and rarely efficient for one company to do everything in-house. Further, the Group Manager explains that Company E is very open and aggressive in its way of motivating its environment and inspiring the Swedish industry. They have been working hard from the start to drive the Swedish AM market forward. And this is something they do because “life is more fun and the market is more exciting when there are more actors competing”.

Figure 4.13 displays a summary of the value creation findings from Company E:
4.2.7 Company F

The respondents are a Business Developer and a Design Manager at Company F.

The Design Manager argues that it is important for companies to identify the benefits which AM technologies can offer as a starting point and then evaluate if there is a business case. Further, he generally believes that it is important for companies to have the ability of identifying which components are suitable for AM production. The Business Developer agrees with this statement and predicts that the companies who possess the most mature knowledge regarding which components are beneficial to realize through printing with AM versus through manufacturing with traditional technologies will have a strong competitive advantage in the AM market compared to those with less matured knowledge in this area.

The Business Developer emphasizes that if components are manufactured in an efficient way with traditional manufacturing technologies, there is no reason at all to start producing the same components with AM instead. Most components need to be completely redesigned to reap the benefits which AM offers. Further, he explains that many companies are currently trying to identify applications for AM, but he believes that AM is not an appropriate technology for all: the best applications for AM are in the manufacturing of complex components made from expensive materials while producing simple components with AM “rarely” are profitable. Also, he says that today, companies have knowledge in how to design components to cast or forge them in the best way but with AM, this competence is not there yet. Today’s designers are too focused on the design for traditional manufacturing and they need to change their mindset in order to fully utilize the potential of AM.
Further, the Business Developer argues that for AM technologies to further mature, experience is more important than more high-performing machines. He says that this is especially important within conservative industries where proof of concept is important. This since, in those industries, extensive validation is required before a new technology can be implemented. He explains that this knowledge and validation is built up from working case by case and for each successful case, more acceptance is gained. Still, he explains that the first AM cases companies works with cannot be expected to turn out completely successful – learning a new technology is costly and the first projects might turn out as failures. However, during this process, knowledge it built up and companies can become better and more cost efficient. Still, the Business Developer emphasize that even though companies should have aims of where they want to end up when entering a new market, the plan and road to get there is very hard to define. Companies simply need to count on making mistakes or revising plans on the “journey”.

The Design Manager says that current AM technologies are relatively mature but agrees with the Business Developer that the associated processes have not yet reached maturity. Still, he is not convinced that it is reasonable for companies to invest in machines to learn AM – he argues that companies “need have something more thought through than that”. The Business Developer, on the other hand, states that it is reasonable for companies to invest in machines to learn about AM. He says that in general, companies are aware of the limitations with AM technologies and can take those into consideration when working with them. However, he says that it is important to be careful not to use the performance of the current technologies as a basis for business cases and decision making. Since the AM technologies will most likely mature further, companies that do this need to be prepared to revise their decisions as the market develops.

Further, the Business Developer cannot say whether it is better for companies to have a broad technological scope or to focus on a niche. He says that this depends on the company’s offering but that it is important for companies to continuously scan the market for new opportunities and update themselves on new AM technologies. The Design Manager, on the other hand, argues that for companies starting their AM journey, it is best to focus on a technology niche or else it will be too difficult to manage.

More, the Business Developer says that is important with partnerships and collaborations to drive the AM market forward. The Design Manager agrees with this statement and explains that Company F is already engaged in several partnerships with other companies which are not direct competitors. The reason for their collaborations is that “AM very easily gets highly niched” and there is often someone else in the market who is more skilled or has more mature knowledge. One example he brings up is the materials; developing materials requires highly specific skills and thus, it might be better for companies which are not niched towards materials to
work with partners instead of developing materials themselves. The Business Developer further states that it is good for companies to engage in collaborations with universities since it can be hard for companies to motivate having large in-house research departments. Here, universities can be helpful in contributing with their research and in turn, companies can contribute with the industry perspective as technologies mature and become adopted. Lastly, the Design Manager sees partnerships and collaborations as a way to cover the value chain for components with tough requirements, especially in high barrier industries:

“We can do it by ourselves to a certain point but we have no possibilities to manage everything by ourselves.”

(Design Manager, 2018)

Figure 4.14 displays a summary of the value creation findings from Company B:

<table>
<thead>
<tr>
<th>THOUGHTS ON CORE ASSETS?</th>
<th>THOUGHTS ON CORE CAPABILITIES?</th>
<th>THOUGHTS ON PARTNERSHIPS AND COLLABORATIONS?</th>
<th>WHERE TO IMPROVE?</th>
</tr>
</thead>
<tbody>
<tr>
<td>“AM processes” are less mature than the machines</td>
<td>Ability of identifying components suitable for AM production</td>
<td>Collaborations with academia to take part of research</td>
<td>AM experience/process knowledge</td>
</tr>
<tr>
<td>Invest in machines to learn AM</td>
<td>Broad or niche technology focus depend on offering</td>
<td>Important with collaborations to drive the market forward</td>
<td>Designer mindset and approach</td>
</tr>
<tr>
<td>Build AM experience</td>
<td>Important to regularly investigate new technologies</td>
<td>No partnerships with direct competitors</td>
<td></td>
</tr>
<tr>
<td>Start in a niche technology</td>
<td>Partnerships to cover the value chain</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.14. Summary of findings from Company F related to value creation.

4.2.8 Summary of value creation empirics

In table 4.2, a summary of all interviewees’ statements regarding value creation is presented in the form of a business model framework developed by the authors and with inspiration from Sinfield et al. (2012). The answers are not describing the company’s own business models, thus they do not for example describe the core assets and capabilities of the company in question but instead what the interviewees believe are generally important assets and capabilities of AM companies. The colors in the table indicate the certainty of the answers; green (G) equals a confident “yes”; yellow (Y) equals hesitation, doubtfulness, or that one company representative is sure of “yes” and the other one sure of “no”; red (R) equals a confident “no”. The answers are presented in an alphabetical order, thus the order in which the findings are presented has not been valued by the authors as having higher or lower importance.
Table 4.2. Summary of findings related to value creation.

<table>
<thead>
<tr>
<th>CORE ASSETS</th>
<th>Universities</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
<th>Company E</th>
<th>Company F</th>
</tr>
</thead>
<tbody>
<tr>
<td>“AM processes” are less mature than machines</td>
<td>Y</td>
<td>G</td>
<td>Y</td>
<td>G</td>
<td>Y</td>
<td>G</td>
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<tr>
<td>Invest in machines to learn AM</td>
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<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Lease machines</td>
<td>R</td>
<td>Y</td>
<td>G</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>CORE CAPABILITIES</th>
<th>Universities</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
<th>Company E</th>
<th>Company F</th>
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</thead>
<tbody>
<tr>
<td>Agility is important</td>
<td>G</td>
<td>G</td>
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<tr>
<td>Ability of identifying components suitable for AM production</td>
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<tr>
<td>Broad technology focus after building competence</td>
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<tr>
<td>Broad or niche technology focus depend on capabilities/ambition</td>
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<tr>
<td>Broad or niche technology focus depends on offering</td>
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<tr>
<td>Build AM experience</td>
<td>Y</td>
<td>G</td>
<td>Y</td>
<td>G</td>
<td>G</td>
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<td></td>
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<tr>
<td>Data analysis capabilities</td>
<td>Y</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td>Designer approach/mindset need to change/expand</td>
<td>Y</td>
<td>G</td>
<td>G</td>
<td>G</td>
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<td>G</td>
<td></td>
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<tr>
<td>Educate workforce</td>
<td>Y</td>
<td>Y</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td>Gather competence</td>
<td>Y</td>
<td>Y</td>
<td>G</td>
<td>G</td>
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<tr>
<td>Important to regularly investigate technologies</td>
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<tr>
<td>Leverage on internal knowledge</td>
<td>Y</td>
<td>G</td>
<td>G</td>
<td>G</td>
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<tr>
<td>Start in a technology niche</td>
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<td>G</td>
<td>G</td>
<td>G</td>
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<td></td>
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<tr>
<td>“Stop talking and start testing”</td>
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<tr>
<td>Use the preferred technology as starting point</td>
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<td>G</td>
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<tr>
<td>The technology is immature</td>
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<td>G</td>
<td>G</td>
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<td>G</td>
<td></td>
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<tr>
<td>Work with the technology to learn it</td>
<td>Y</td>
<td>G</td>
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</table>

<table>
<thead>
<tr>
<th>PARTNERSHIPS AND COLLABORATIONS</th>
<th>Universities</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
<th>Company E</th>
<th>Company F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A spider web with customers, partners, suppliers</td>
<td>G</td>
<td>G</td>
<td>G</td>
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<td>A way to access “hyped” markets</td>
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<tr>
<td>A way to access new AM markets</td>
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<tr>
<td>Collaborations with academia to take part of research</td>
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<tr>
<td>Do not believe in complete openness</td>
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<td>Fewer collaborations will give higher share of return</td>
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<td>G</td>
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<td>Important to create a critical mass</td>
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<tr>
<td>Important with collaborations to drive the market forward</td>
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<td>Important with partnerships in high-barrier industries</td>
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<td>New approach towards partnerships is required</td>
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<td>No partnerships with direct competitors</td>
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<tr>
<td>Partnerships downstream in supply chain (competing)</td>
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<td>Partnerships to cover the value chain</td>
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<thead>
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<th>AREAS OF IMPROVEMENT</th>
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<td>AM competence</td>
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<td>AM experience/process knowledge</td>
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<td>Automation degree</td>
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<td>Component size</td>
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<td>G</td>
<td></td>
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<tr>
<td>Costs</td>
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<td>G</td>
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<td>G</td>
<td>G</td>
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<tr>
<td>Designer mindset and approach</td>
<td>G</td>
<td>G</td>
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<td>G</td>
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<tr>
<td>Development of standards</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Machine maturity</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td>Material knowledge</td>
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<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
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<tr>
<td>Material price</td>
<td>Y</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Material quality</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
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<td></td>
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<tr>
<td>Post-processing</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
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<td></td>
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<tr>
<td>Serial production</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Software</td>
<td>G</td>
<td>G</td>
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<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
</tr>
</tbody>
</table>
4.3 Value capture

Below, the empirics regarding value capture are presented. This includes desired customer relations, powerful positions in the value chain, and access to the offerings. After each organization’s empirics are presented, a summary of the respective organization’s statements will follow. The summary is color coded with colors indicating the level of certitude and confidence of the answers; green equals a confident “yes”; yellow equals hesitation or doubtfulness, or that one company representative is sure of “yes” and the other one sure of “no”; red equals a confident “no”. The statements are presented in an alphabetical order in the summary.

4.3.1 Universities

The respondents are a Professor from University A and a Research Director at University B.

The Research Director believes it is good to have close customer relations when working with AM, and that companies working as providers of AM offerings first should have a full solution in place and then pursue development projects together with customers through an interactive and iterative process. The Professor believes that collaborative development will be a part of the business and states that often, it is impossible for companies to develop offerings without customer engagement:

“If an AM company starts doing some development for, for example, the automotive industry without engaging with them, that will not be feasible. Because it will require a lot of resources and time while not knowing if it is the right way forward.”

(Professor, 2018)

Regarding which part of the value chain that is considered to be most powerful or advantageous, the Research Director mentions machine manufacturers – he says that they will still play an important role for a while to establish process parameters and quality assurance systems. However, in the future, he sees the power shifting to AM designers along with material suppliers, as material suppliers will likely develop process related parameters together with customers:

“A thing that will happen in the coming years is that material suppliers will bring more knowledge into the the area; they will have a stronger impact on material and processes. They will be able to supply materials that satisfy AM and provide process related parameters.”

(Research Director, 2018)

The Research Director also states that each step in the value chain is capable of achieving good margins and gives two examples of areas: materials and the connection of post-processing together with a design thinking. At the same time, the Professor believes that being a service provider is one of the most beneficial positions a company can take for the moment – that is “where the money is”.

66
However, in the future, the Professor believes that the winners in the AM market will be those with the most developed and mature knowledge base.

Figure 4.15 displays a summary of the value capture findings from the universities:

<table>
<thead>
<tr>
<th>Which are the desired customer relations?</th>
<th>Which companies will have most power in the value chain?</th>
<th>Thoughts on access to offering?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close relations</td>
<td>Companies offering process parameters</td>
<td></td>
</tr>
<tr>
<td>Development projects with customers (with a mature solution in place)</td>
<td>Currently: machine manufacturers</td>
<td></td>
</tr>
<tr>
<td>Interactive and iterative processes with customers</td>
<td>Currently: service providers</td>
<td>Each step in the value chain is capable of achieving high margins</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the future: AM designers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the future: companies with most matured knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the future: powder suppliers providing process parameters</td>
</tr>
</tbody>
</table>

Figure 4.15. Summary of findings from the universities related to value capture.

4.3.2 Company A

The respondents are the CTO, the Operations Manager and the President from a spin-off organization within Company A.

Currently, the Operations Manager is under the impression that machine manufacturers and software providers have much power when it comes to how AM technologies will develop. However, he believes, but is not sure, that this will change as AM probably will become a standardized way of producing components. Then, end-customers will probably demand lower prices for standard components. Thereby, the power will shift to end-customers, perhaps together with software providers. He also believes that companies will be able to earn money on providing end-to-end solutions. However, companies solely selling materials will probably be pressured by cheaper material suppliers which are entering the market if they do not offer patented processes, such as process parameters, associated with the material, perhaps in collaboration with machine manufacturers.

The CTO believes that companies offering an “unbroken” end-to-end solution, particularly in high barrier industries, would hold attractive positions. This since he believes that companies lose control if they use suppliers for some parts of the value chain. He also believes that high margins will be achieved at companies giving customers access to the “right competence”, meaning the best AM knowledge.
Currently, he sees the margins being earned by software providers but he also believes that high margins can be achieved by selling prototypes. However, he believes that companies should not base their whole business on prototypes because of limited economies of scale, due to the heavy investments that must be made in all the required equipment.

Regarding customer relations, Company A has a tradition of working long-term with customers to develop their next generations of products. And this will not change in the AM initiatives; the Operations Manager believes that companies should create standard AM offerings and then work together with customers in development projects. This since the close relations throughout the development projects will be important for companies to learn and build even more knowledge. The CTO agrees with this statement and adds that he hopes to see customers approaching Company A with components to manufacture and that Company A can help and educate them in their “AM journey”.

Figure 4.16 displays a summary of the value capture findings from Company A:

<table>
<thead>
<tr>
<th>WHICH ARE THE DESIRED CUSTOMER RELATIONS?</th>
<th>WHICH COMPANIES WILL HAVE MOST POWER IN THE VALUE CHAIN?</th>
<th>THOUGHTS ON ACCESS TO OFFERING?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close relations</td>
<td>Companies offering digital services (software)</td>
<td></td>
</tr>
<tr>
<td>Development projects with customers</td>
<td>Companies offering knowledge</td>
<td></td>
</tr>
<tr>
<td>Long-term relationships</td>
<td>End-to-end solution providers</td>
<td>In the future: end customers</td>
</tr>
<tr>
<td></td>
<td>Currently: machine manufacturers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Powder suppliers (without additional services)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.16. Summary of findings from Company A related to value capture.

4.3.3 Company B

The respondents are the CEO and the Sales Manager at Company B.

The Sales Manager does not believe in approaching customers before having a solid offering. He says that doing development projects together with customers at an early stage is like buying a lottery ticket since the market is still so immature. It is still too early to say which companies will succeed or fail. Further, he argues that customers do not want to pay for their suppliers to learn. On the other hand, he says that learning about successful AM cases causes stress for companies to launch their
own AM initiatives and the CEO agrees with this statement and says that it is a race to market where companies are stressing each other. However, the CEO does not believe that it is an appropriate strategy for companies to develop their offerings without the involvement of customers, and then launch the offering when it is considered to be “full” or “perfect”:

“Where AM is today, and if you go for that strategy, then it is no longer your market when you are finally entering; the market will have gotten ahead of you. So the only way to stay in the forefront here is to grab the hands of the others running the same race. And to learn from each other and be there throughout the whole journey.”

(CEO, 2018)

Further, both the CEO and the Sales Manager say that the actors who can help their customers throughout the AM process, thus offering end-to-end solutions, will be the ones having most power in the value chain. Also, the Sales Manager believes that software will be the key to reduce costs and reduce the current complexity of the process. Similarly, the CEO specifically believes that companies with a “digital backbone” that can provide end-to-end solutions will be successful while machine manufacturers will have reduced power in the future. He also believes in providing customers with the complex process parameters, as also stated in the subchapter 4.1.3 Company B regarding value proposition:

“I believe in the “digital backbone”. I think that machines will be commodities within a few years. So instead, what will be most valuable will be to have the best network in terms of how to connect the different processes in order to get from A to Z. And the knowledge about process parameters and different combinations of those - how to achieve the best possible output. That is the key success factor.”

(CEO, 2018)

Figure 4.17 displays a summary of the value capture findings from Company B:

<table>
<thead>
<tr>
<th>VALUE CAPTURE: Company B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHICH ARE THE DESIRED CUSTOMER RELATIONS?</strong></td>
</tr>
<tr>
<td>Development projects with customers</td>
</tr>
<tr>
<td><strong>WHICH COMPANIES WILL HAVE MOST POWER IN THE VALUE CHAIN?</strong></td>
</tr>
<tr>
<td>Companies offering digital services (software)</td>
</tr>
<tr>
<td>Companies offering process parameters</td>
</tr>
<tr>
<td>End-to-end solution providers</td>
</tr>
<tr>
<td>In the future: machine manufacturers</td>
</tr>
</tbody>
</table>

*Figure 4.17. Summary of findings from Company B related to value capture.*
4.3.4 Company C

The respondents are a Board Member from the organization which Company C is a spin-off from, and the General Manager and the Sales Manager at Company C.

According to the Sales Manager, Company C works with large companies that continuously place orders on their AM offerings. He further explains that customers sometimes want to work with Company C in close development projects, often regarding highly complex products, and sometimes they do the opposite and request serial production without much of a dialogue. The General Manager says that he prefers to work closely and long-term with customers; he does not believe in only targeting temporary customers who are looking for low prices. The Board Member believes that a good approach is to establish relations with the customer at the end of the supply chain in order to drive demand and he gives an example from the automotive industry:

“In [Company name], you find a great example. They have approached the end-customers in the automotive industry who has in turn set demands backwards to sub-suppliers to use [the Company’s] technology. So they have approached the end-customers to make them set the demands. And I believe that this is exactly what companies should do with AM as well.”

(Board Member, 2018)

Since many companies are offering similar solutions, the General Manager simply believes that the companies that will be most successful are the ones with the “best offerings”. He currently believes that the machine manufacturers are the ones influencing the market the most but that they are not making a lot of money. Further, he says that fewer and fewer of the machine manufacturers probably will offer materials in the future. The Sales Manager believes that material suppliers will be powerful AM actors since they will decide the price on one of the core components of AM. On the other hand, he sees that new actors can arise and offer better prices in the future and then it will instead be a matter of supply and demand. The Board Member, on the other hand, says that with the right business model, any company can achieve high margins independently of where they operate in the value chain. Currently, he believes that being a print shop is a good position to have. However, this will probably not be the case over time since many customers might buy the technologies themselves when the market has matured. Still, he believes that the most attractive offering will be to provide customers with process parameters:

“The company that becomes the best in combining materials and different AM technologies to enable exactly what the customer requires – that company will be able to control its profit margin very well.”

(Board Member, 2018)

Figure 4.18 displays a summary of the value capture findings from Company C:
4.3.5 Company D

The respondents are an Engineering Leader and an Engineering Manager at Company D.

To capture value from AM offerings, the Engineering Leader believes that close customer relations are important; at Company D, they run development projects with customers where they work with design iterations to customize components. Further, the Engineering Leader says that companies need to be careful and ensure that they understand their customers’ problems:

“I think it is important to have a close contact with customers in this case, when it comes to AM, in order to find solutions to problems that we cannot solve today. We might have an idea of what we think the customers’ problems are, but it is not certain that the customers can formulate it. But we can have this close dialogue. We are quite open and we want this dialogue and receive input.”

(Engineering Leader, 2018)

The Engineering Manager is skeptical to the idea of approaching external customers with the proposition of making an “AM journey” together, thus not having a solid offering from the start but rather working in development projects together with customers. To engage in such development projects, the Engineering Manager argues that the company needs to be significantly more skilled than the customer:

“The customer needs to have a will to work with you specifically. And the customer will compare you against your competitors, who wants to do them same thing, and ask: ‘why should I choose you to help me with this?’ And then you need to have a very good answer to that question.”

(Engineering Manager, 2018)
However, while the Engineering Manager believes that customers do not want to pay for their suppliers to learn, he also says that there can be special reasons for a customer to choose a specific supplier even though it is not the strongest AM actor:

“However, there may be other synergies, there might be a history… Maybe a product knowledge or a domain knowledge so that the company can claim that ‘we know AM and we also know something else that makes us very interesting in this niche or area. We are unique because we have other knowledge’. [...] It could be that you are a supplier who is very appreciated and who is supplying to a customer in many other areas. If that supplier wants to become a partner also within AM, then it might not matter that they are not the best. Another example is if you are very good at materials, for example. Then you can say that ‘we have a long history of materials; we might not know everything about AM but we are very good at materials so we will learn AM fast’.”

(Engineering Manager, 2018)

The Engineering Manager argues that the machine manufacturers are currently the ones with most power in the value chain. His view is that the machines are still complicated and expensive and he does not see any indications for this to change in the near future. Thus, he believes that this power will remain with the machine manufacturers, but also shift towards material suppliers since customers will probably start buying material directly from them in the future. This would be a way for customers to reduce the number of intermediaries and thereby also prices. Further, the Engineering Leader predicts that the companies which can provide customers with end-to-end solutions will be the strongest players and they will also be the ones who are able to capture most value from AM. He says that the companies that master the whole value chain and are niched in metals will be very powerful:

“Customers will come to them and say that they have this idea and ask, ‘can you help us realize it?’. And these companies will be able to charge a lot of money because the price tag of entering the AM market and deliver large volumes is so high that only large companies will be able to do it. It is capital intense and above all, it takes a long time to build the knowledge.”

(Engineering Leader, 2018)

Figure 4.19 displays a summary of the value capture findings from Company D:

<table>
<thead>
<tr>
<th>VALUE CAPTURE: Company D</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHICH ARE THE DESIRED CUSTOMER RELATIONS?</td>
</tr>
<tr>
<td>Close relations</td>
</tr>
<tr>
<td>Development projects with customers</td>
</tr>
</tbody>
</table>

*Figure 4.19. Summary of findings from Company D related to value capture.*
4.3.6 Company E

The respondents are the Group Manager and the CTO at Company E.

Both the CTO and the Group Manager believe that close customer relations are absolutely necessary. The Group Manager also says that the best way to work with customers is to engage in strategic partnerships with them:

“The best way is probably to create strategic partnerships with your customers. You promise to never reveal any information or secrets. And you of course have non-disclosure agreements and confidentiality agreements. And you visit the customer often; you proactively seek up designers and product owners. This is what I have done. I have made this journey internally at [Company E]. I have worked hard and repeatedly asked for jobs.”

(Group Manager, 2018)

The CTO says that at Company E, they believe that the best way is to start working case by case with customers to prove the added values that they can offer. Further, the CTO explains that Company E also engage in AM development projects with customers, something he calls “customer co-creation”. The Group Manager also believes that making an “AM journey” together with the customers and entering the market even though the offerings are not yet fully developed, is important. He says that if a company is capable of offering its customers a “perfect” solution right away, then they should of course do that. However, if the resources are not in place to achieve this yet, he still believes that it would be outrageous for companies to wait until everything is perfect, since it will then be too late; “the important thing is to get a foot into the market. Then, when you are in there, you will grow together with the other actors”. Also, the Group Manager says that despite the market still being highly immature and the demand from customers is small, there is still a race to the market: it is critical to enter the market early, or the “early bird status” will be lost.

The Group Manager believes that the actors with most power in the value chain will be those who can create additional value for their customers by developing customized offerings and guidance through the whole value chain:

“You need to create additional value; discuss with the customer what he or she wants. You need to be able to prepare and alter the customer’s design into something that is printable. You need to be able to simulate the building process in order to foresee problems. Those are unique selling propositions; to be able to offer the customer a thorough value chain.”

(Group Manager, 2018)

Further, the Group Manager does not believe that print shops will have a beneficial or powerful position in the market in the future. This since he is convinced that the actual printing will soon become a commodity and thus, gain low status. He draws the parallel to paper print-shops which were common in the 90’s:
“Paper print shops do not exist in Sweden anymore since everyone has a paper printer at home. And it is not cool to own a paper printer. And this is what will happen to metal printing as well.”

(Group Manager, 2018)

However, the Group Manager believes that it can still be a good idea to have printing as part of an offering to cover the value chain. This even though he thinks that the actual printing will not offer high margins. According to him, the high margins will instead be related to material, design, process simulation and development of process parameters. Also, the CTO believes that the most power in the value chain will be with the actors who supply materials and enable higher productivity. He says that the current materials are too expensive, thus not acceptable for wider use, only for complicated components. He also believes that it will be attractive to focus on AM design but does not believe that machine manufacturing will be a good strategy.

Figure 4.20 displays a summary of the value capture findings from Company E:

<table>
<thead>
<tr>
<th>WHICH ARE THE DESIRED CUSTOMER RELATIONS?</th>
<th>WHICH COMPANIES WILL HAVE MOST POWER IN THE VALUE CHAIN?</th>
<th>THOUGHTS ON ACCESS TO OFFERING?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close relations</td>
<td>AM designers</td>
<td>Do not wait for the “perfect” offering</td>
</tr>
<tr>
<td>Development projects with customers</td>
<td>Companies enabling higher AM productivity</td>
<td>It is a race to the market</td>
</tr>
<tr>
<td>Strategic partnerships</td>
<td>Companies offering customized solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Companies offering process parameters</td>
<td></td>
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<tr>
<td></td>
<td>End-to-end solution providers</td>
<td></td>
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<tr>
<td></td>
<td>Powder suppliers</td>
<td></td>
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<tr>
<td></td>
<td>Machine manufacturers</td>
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<tr>
<td></td>
<td>Print shops</td>
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</tbody>
</table>

Figure 4.20. Summary of findings from Company E related to value capture.

4.3.7 Company F

The respondents are a Business Developer and a Design Manager at Company F.

According to the Design Manager, Company F both works in long development projects with customers and cases where customers already have a demand. For example, some customers ask for AM as an alternative to their current production methods. Further, the Design Manager says that it can be an option for companies to have a mixed business model of AM development and production.
The Design Manager believes that companies often need to engage in development projects together with customers – without customer involvement, it will almost be impossible to develop a “perfect”. The Business Developer agrees with this statement and says that with AM, it is necessary to have close customer relations. Further, he emphasizes the importance of feedback from customers in order to develop attractive offerings.

The Business Developer says that there is an ongoing hysteria with AM, but that the technology has passed the stage where companies are just “showing off” complex designs. He says that now, it has come to the point where companies actually need to prove the functional viability of their offerings. The Business Developer argues that the companies that becomes superior in designing components so that they suit the AM process will have a strong position in the market. The Design Manager, on the other hand, is not sure which actors will have most power but believes that companies with a developed AM knowledge base will have a good starting point.

Figure 4.21 displays a summary of the value capture findings from Company F:

<table>
<thead>
<tr>
<th>VALUE CAPTURE: Company F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHICH ARE THE DESIRED CUSTOMER RELATIONS?</strong></td>
</tr>
<tr>
<td>Close relations</td>
</tr>
<tr>
<td>Development projects with customers</td>
</tr>
<tr>
<td>Development projects with customers (with a mature solution in place)</td>
</tr>
<tr>
<td>Feedback from customers is important</td>
</tr>
<tr>
<td><strong>WHICH COMPANIES WILL HAVE MOST POWER IN THE VALUE CHAIN?</strong></td>
</tr>
<tr>
<td>AM designers</td>
</tr>
<tr>
<td>Companies with most matured knowledge</td>
</tr>
<tr>
<td><strong>THOUGHTS ON ACCESS TO OFFERING?</strong></td>
</tr>
<tr>
<td>It is a race to the market</td>
</tr>
<tr>
<td>Showing off is over – the market needs proof of concept</td>
</tr>
</tbody>
</table>

*Figure 4.21. Summary of findings from Company F related to value capture.*

### 4.3.8 Summary of value capture empirics

In table 4.3, a summary of all interviewees’ statements regarding value capture is presented in the form of a business model framework developed by the authors and with inspiration from Sinfield et al. (2012). The answers are not describing the company's own business models, thus they do not for example describe the customer relations of the company in question but instead what the interviewees believe are generally desirable customer relations for AM companies. The colors in the table indicate the certainty and confidence of the answers; *green (G)* equals a confident “yes”; *yellow (Y)* equals hesitation or doubtfulness, or that one company representative is sure of “yes” and the other one sure of “no”; *red (R)* equals a confident “no”. The answers are presented in an alphabetical order, thus the order in which the findings are presented has not been valued by the authors as having higher or lower importance.
### Table 4.3. Summary of findings related to value capture.

<table>
<thead>
<tr>
<th>SUMMARY OF FINDINGS: VALUE CAPTURE</th>
<th>Universities</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
<th>Company E</th>
<th>Company F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CUSTOMER RELATIONS</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Close relations</td>
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<td>G</td>
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<td>G</td>
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<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Development projects with customers</td>
<td>G</td>
<td>Y</td>
<td>G</td>
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<tr>
<td>Development projects with customers (with a mature solution in place)</td>
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<tr>
<td>Feedback from customers is important</td>
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<tr>
<td>Interactive and iterative processes with customers</td>
<td>G</td>
<td>G</td>
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<tr>
<td>Long-term relations</td>
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<tr>
<td>Relations with actors in the end of the value chain</td>
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<tr>
<td>Strategic partnerships</td>
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<tr>
<td>Weak relations</td>
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<td>G</td>
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<td>G</td>
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<tr>
<td><strong>POWER IN VALUE CHAIN</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>AM designers</td>
<td>G</td>
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<td>G</td>
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<td>In the future: companies with most matured knowledge</td>
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<td>In the future: end-customers</td>
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<td>In the future: machine manufacturers</td>
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<td>It is a race to the market</td>
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<td>Showing off is over – the market needs proof of concept</td>
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<td>Unique knowledge or relations in other areas can be beneficial</td>
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This chapter presents the identified common themes from all companies and universities and further analyze these in relation to theory. In the end of each subchapter, the alignment of the common themes is analyzed and finally in the end, the alignment of all common themes are analyzed in relation to each other.

5.1 Analysis of value proposition empirics

The identified common themes regarding the value proposition are: immature demand, internal cases as a starting point, knowledge offering, end-to-end solutions, broad customer focus. The themes are further elaborated below.

**Immature demand**
Both companies and universities have mainly identified demands for functionalities which can be enabled through AM, rather than a demand for AM per se. However, exactly which demands that are brought up vary: both Company D and E argue that customers demand improvements of current offerings while, for example, University A has identified a demand for customized products and University B has identified a demand for reduced inventory. More examples are Company A, where demands for complex structures have been identified, and Company C, which has identified demands for fewer assembly steps and a higher degree of detail. The demands identified by the universities and companies overlap to a large extent with the most frequently mentioned benefits of AM from theory; Conner et al. (2014) and Bacchetti et al. (2016) describe AM as an enabler for complex structures and reduction of assembly steps while Ber-Ner and Siemsen (2017) and Conner et al. (2014) emphasize that AM will increase customization. The differences in the demands mentioned by the companies and universities implies that the demands for AM might differ depending on customers and industries.

The main common theme among the identified demands for AM per se is the demand for AM knowledge. This is mentioned by Company A, B and D. For example, the Engineering Manager at company D says that many actors which are entering the AM market at this point need someone to “hold their hand”. At Company C, on the other hand, most customers who approach have clear ideas of their demands and only a few are demanding AM knowledge. Again, this might imply
that demands differ across industries but that in most industries, the demand for AM is not yet mature and customers are not sure of what they want or need. This is further emphasized by Company D and E who both state that the demand for AM is low (according to Company E it is almost non-existing).

An immature and low demand for AM implies that Swedish companies should be careful when using Gartner’s (2018) hype cycle as a tool to judge the state of the AM market. This since the cycle indicates a hype which might not be true among Swedish customers. The cycle might be more true for other countries which have come further in their AM maturity. Company E calls Sweden a developing country when it comes to AM, indicating the Swedish AM market is lagging behind others. Further, even though there might be an ongoing AM hype among certain actors, other segments of the market might not even have considered AM yet. Therefore, companies should not use their own interest in AM technologies as the only indicator that there is a demand for AM. Instead, it is important to engage with potential customers to make sure that their needs and demands are understood. In other words, companies should strive for having close customer relations. This is also supported by Teece (2017), who argue that a good business model requires deep knowledge of customer needs.

More, it is important for companies to continuously review the demands on the market. If a company is setting up a business model based on today’s (possibly) immature demands, it needs to be prepared to revise it later since demands are likely to change with increased maturity. As proposed by Sinfield et al. (2012): the business model should be treated as a variable instead of a constant.

**Internal cases as a starting point**

University A and Company A and D (and to some extent Company C) argue that a good starting point for companies working with AM is to build up internal cases. Company A and D suggest that this helps to increase a company’s credibility. Also, Company D, E and F all argue that AM should be used to improve current offerings if possible and this could further strengthen the argument that an internal starting point is suitable. Building on this, Company B, C and D argue that the company’s core business is an appropriate starting point to any AM initiative; thus, if the company originally is a software provider, AM initiatives should initially have a software focus.

Company B is the only company not mentioning an internal starting point. The Sales Manager at Company B instead emphasize the importance of external customers at an early stage as a proof of concept. However, not mentioning that internal cases are an appropriate starting point does not have to mean that Company B believe it is a bad idea. Instead, the reason why this was not brought up can rather have to do with the fact that Company B is a joint venture and therefore have a more external focus. Another reason is that not all companies have the possibility to work with external
cases. More, the General Manager at Company C argues that internal cases are not more “safe” than external: a failure would not matter less just because the customer is from within the company. This argument indicates that internal customers also can work as proof of concept in contrast to the arguments by the Sales Manager at Company B.

It is becoming clear that there is no one-size-fits-all strategy for AM, as also argued by Hao et al. (2014). Instead, each company must use its own unique capabilities as a starting point. Still, based on the discussions regarding the starting point for AM initiatives, internal cases (if the possibility exists) are appropriate.

Knowledge offerings
The common theme for attractive offerings, and also one of the most frequently mentioned suggestions of an attractive offering, is knowledge. This is brought up by the universities and Company A, B and to some extent F. Knowledge as an attractive offering could either be indicating that the AM market is still immature (as was discussed above regarding the current demands for AM) or that AM is a niche technology where few actors will possess most of the knowledge. Company A argues that one of the reasons why knowledge is considered an attractive offering is because it would be hard to copy. This relates to business model theories from Kindström (2010) and Teece (2010) where an important factor in the creation of a business model is argued to be the achievement of a non-imitable design. When implementing a business model, systems, processes and assets which are hard to replicate are often required (Teece, 2010) and knowledge which has been built up for a long period of time could serve as such an asset.

Another potentially attractive offering, closely related to knowledge, is to provide customers with process parameters, meaning that companies should be able to guide customers to the right combination of material, machine parameters and component design to optimize the end result. The development of process parameters is one of the most complex part of the AM value chain and something few companies can manage themselves. Process parameters were mentioned as a potentially attractive offering by Company A, B, C, D and E.

The common theme in the offerings which are suggested as potentially attractive is again related to AM knowledge. Like the demand, the offerings which are considered being most attractive to the current market indicate market immaturity. Again, this is something companies need to be aware of when developing their business models and thus, they also need to be prepared to update them in the future.

Two offerings which are brought up more than once as unattractive are offerings which competes with actors downstream in the supply chain, as mentioned by University B and Company C, and offerings consisting of only the printing service, as mentioned by Company A and E.
**End-to-end solutions**

Several companies argue that a success factor will be to provide customers with end-to-end solutions. In other words, guiding the customer through all steps of the value chain. This is mentioned as both a potentially attractive offering and in regards to where to operate in the value chain. Companies A, D and E and University B are all certain that end-to-end solutions will be attractive but emphasize that only a few companies will be capable of providing them. However, as also suggested by Companies A, D and E, partnerships and collaborations with other actors can be a way of providing end-to-end solutions without having all competence in-house.

Company F, on the other hand, believes that end-to-end solutions will be as good as focusing on a niche of the value chain but Company D argues that covering the AM value chain might become necessary for companies due to the highly intertwined steps of the AM value chain. This can be connected to theory by Andel et al. (2014) who argue that the high degree of computerization is one of the main drawbacks of AM. Several parties, for example the designer and the manufacturer, require access to the IP in order to produce an AM component and the more actors that are involved, for example through outsourcing, the more challenging the IP protection will become.

Company B is divided regarding how much of the value chain that needs to be covered. The CEO believes that an end-to-end approach is critical while the Sales Manager is convinced that no companies will be able to manage end-to-end solutions in an efficient way. Therefore, he believes that it is better for all actors to focus on a niche. However, at another point during the interview, the Sales Manager says that he believes that it is important for companies to have competences in the whole value chain but that this competence should be for a niche technology. Thus, his opinions in this matter are ambiguous.

As described in the subchapter 2.1.1 *The additive manufacturing process*, the AM value chain starts with the conceptualization and design of the component and ends with post-processing after the component has been printed (Gibson et al., 2010). In contrast to the other companies, Company C says that they have not identified a demand for the design part of the AM value chain. University A agree with this statement and argue that customers will want to do the designs by themselves. However, besides design, both University A and Company C are also positive to providing customers with end-to-end solutions, even though they do not consider it to be necessary for success.

In the companies’ and universities’ discussions regarding the value proposition, end-to-end solutions are frequently mentioned, and mostly in positive terms. However, companies need to be aware that not all actors are capable of acting as end-to-end solution providers. Thus, all companies must assess their own capabilities when deciding their scope.
Broad customer focus

Company A, C and E and University A believe that it is good for companies to have an open mind and a broad focus when targeting customers. However, even though Company E believes this is the right approach, the Group Manager still emphasize that there is a lack of customers on the market, which might force companies to become more niched. Building on the Group Manager’s arguments, the Engineering Leader at Company D also believes that it will be natural for companies to target a niche segment of customers due to the differing demands across industries. However, the Engineering Leader is still positive to a broad customer focus if the company is capable of it. The Engineering Manager at Company D, on the other hand, believes that targeting a niche is best due to the high barriers which characterize most AM industries. Company F also argues that targeting a niche would be best since a broader customer focus would be hard to manage.

Further, even though both Company C and University A believe that a broad focus is good, they still argue that a company’s choice of AM technology and offering will affect which customer will be interested, and thus decide a customer niche. As described in chapter 2.1.2 Additive manufacturing technologies, there are several different AM technologies in the market and these differ significantly in how they create value and how they are used (SmarTech, 2017). Since different technologies are used for different purposes, Company C and University A might be right that the target customers for each technology also will differ. Thus, if a company decides to choose a narrow technology niche, the target customer segment will automatically become more narrowed and vice versa. Still, this does not mean that companies with a narrow technology niche cannot have open minds when targeting customers.

Companies being positive towards having an open mind and broad focus when targeting customers might be another indication that the AM market is still immature it is not yet obvious which are the most attractive customers. However, according to Teece (2017), identifying which customer segments to focus on is critical to ensure business model viability. Thus, the empirical findings regarding customer segmentation to some extent contradict the theory and therefore, this might be an area which the companies need to spend more time considering.

Alignment of common themes: Value proposition

As discussed in chapter 3.5 Data Analysis, the interrelation of the different themes should be examined since different combinations of the themes can create different outcomes (Sinfield et al., 2012). Also, some business model components can automatically eliminate others. Regarding the value proposition, the most discussed themes includes offering AM knowledge and/or end-to-end solutions and starting with internal customers and then having a broad external customer focus. These themes can somehow be argued to contradict each other, since offering AM knowledge can be considered difficult when targeting a broad range of customers, if the knowledge thereby needs to cover many technologies. This since it most likely
will require a lot of resources, time and investments to build this knowledge base to serve many different demands and requirements. However, the themes are not argued to contradict each other if the idea is to start with internal customers and then step by step expand into different external customer segments, since building the knowledge that the company will offer thereby will be a more manageable process.

5.2 Analysis of value creation empirics

The identified common themes regarding value creation are: start in a technology niche and then expand, invest in machines to learn AM, change in designer mindset is required, partnerships to drive the AM market forward. The themes are further elaborated below.

*Start in a technology niche, then expand*

Four of the companies, Company B, C, E and F, mention the benefit of starting in a technology niche instead of directly investigating all, or many, available technologies. According to Company B and F, the reason is because it simply will be a more manageable approach and Company E believes that becoming good at one thing first will be the only possible way for most companies. The Business Developer at Company E explains that companies build up knowledge from working case by case and even if the experiments fail sometimes, knowledge will still be captured. Similarly, that failed experiments can lead to new data giving directions towards previously latent opportunities, is also stated by Chesbrough (2010) and Thomke (2003). Further, by doing experiments early and often, managers can collect information to make better decisions (Thomke, 2003).

The views on whether companies then should expand into other technologies differ among the interviewees. The universities and Company C, D and F believe that it depends on the company: the universities argue that it depends on the company’s core and similarly Company C argue that it depends on the company’s strategy, ambition and resources. Company D says that it depends on the size of the company and its target customers and Company F says that it depends on the offering. The universities and companies give similar explanations for whether companies should expand into working with several technologies.

Company B believe that all companies should go for a technology niche but that it still is good to have a relatively broad understanding of AM. Company A and E on the other hand believe that companies should have a broad focus and investigate different possibilities. As stated by Company A, companies can first evaluate which technology suits their internal products or core business and then limit the expansion when it starts to slow the company down. Company E argues strongly that companies should not limit themselves to only one niche technology in the long run, especially not large companies working with complicated products. This since they need to understand how different technologies can be utilized for different
components, and also since the step towards a new technology will be smaller each time a company does it. Further, Company E states that it is important to stay updated with the new technologies that constantly arise. Again, the answers may vary due to different backgrounds and maturity of the companies which indicates that there is no right or wrong answer to this question, that there is no one-size fits all AM strategy, as also Hao et al. (2014) states. In chapter 5.1 Analysis of value proposition empirics, the universities and Company A, B and to some extent F have argued that knowledge is an attractive offering (similar to the demand) and process parameters were mentioned as a potentially attractive offering by Company A, B, C, D and E. The finding from this chapter is that it can be beneficial to start in a niche technology and then expand into other technologies depending on your strategy, to learn about AM. Combining the findings from these two chapters indicates that some companies should go into only a few technologies and build up so much knowledge so that customers demanding AM knowledge and/or process parameters will approach them, and that other companies should expand into several technologies and build the same knowledge base but within more areas. Hence, it will again depend on the capabilities of the company whether or not it is possible.

Invest in machines to learn AM

When having decided the width of the technological focus, companies need to decide whether to invest in AM machines or not. The universities, Company A, D and E all agree on that it is good to invest in technologies to learn about AM, similar to a conclusion by Sinfield et al. (2012) which states that investments in product development to produce better offerings is one of the ways to pursue growth. Company A reason that the current machines will not be outdated in the coming years and Company C argue that the investments will pay off quickly for companies producing highly complex products. Further, Company D state that AM is mature enough to count for the investments and that is important to have the courage to invest to not “miss the train”. Lastly, Company E argues that the only reasonable thing to do to is to invest in AM machines, even though the Group Manager at Company E does not believe the machines have reached full maturity:

“Of course you need to invest in the technology. The way I see it, if you want to be an active actor in the market, you have no other choice. You need to master the successes and the problems. You need to be able to explain to the customer what to do when problems occur. And you can only do that if you have your own machine. You cannot learn this by reading in a book, you need to ‘live’ the manufacturing. You need to discover the problems yourself.”

(Group Manager at Company E, 2018)

This indicates that it is reasonable for companies to invest in machines (starting from a technology niche, then perhaps expand) to learn about AM.

Company B, on the other hand, believes that the risk of investing in machines to learn about AM is too big. This since they consider even the best machines to be too
immature and that they are still rapidly developing. Company F is more divided; the
two interviewees are on different sides whether it is reasonable to invest in machines
or not. The Design Manager at Company F says that current AM technologies are
relatively mature but is still not convinced that it is reasonable for companies to
invest in machines in order to learn AM – he says that companies “need have
something more thought through than that”. The Business Developer at Company
F, on the other hand, states that it is reasonable for companies to invest in machines
to learn about AM but that companies who do this need to be prepared to revise
their decisions since the AM technologies will mature further, meaning that the
business model should be treated as a variable and not as a constant, as Sinfield et al.
(2012) express it.

An option to investing in machines is to lease them. This is mentioned by three
companies; Company A, B and E. The CTO at Company E believes that leasing is
an option for companies who are not willing to make investments in machines. The
CEO at Company B believe that leasing machines is the best strategy now to retain
flexibility and reduce risks. Company A is of another opinion where the Operations
Manager believes it is better to invest in machines since the company then can modify
the machines as it wishes without having to return it in a certain state (as for leasing).

Most arguments regarding whether it is reasonable to invest in technologies involves
technological maturity. The investigated companies are likely to work with different
technologies which could be a reason for the different views on the maturity level.
Many companies agree that the technologies are not fully matured but that it still is
good to do the necessary investments to learn about AM, but each company also
needs to identify the benefits (and risks) it could bring.

Change in designer mindset required
Company B, C, D, E and F all bring up the same challenge of the designers’ mindset,
meaning that a common problem among companies is to implement a new way of
thinking among their designers. Company C and F explain that they have had
problems with educating designers to not only focus on traditional manufacturing
methods and Company E believe it is a general lack of AM competence. Hence, the
designer mindset is one of the main areas where change is required. Similarly, both
the universities and Company B see that a challenge for companies is to find the right
competence and also that companies need to make sure that they educate employees
within the companies. The universities believe that they, and other universities, have
an important role to play in this.

The findings indicate that companies should be aware that a common internal
challenge with AM is to change the mindset of current workforce towards thinking
not only about traditional manufacturing methods but also about AM. Thus,
companies should make efforts to educate their current workforce in AM. However,
as discussed in chapter 5.1 Analysis of value proposition empirics, the design of AM
components is still likely to be done by the customers themselves to a large extent according to Company C and University A. This indicates that a change in mindset is required among customers’ designers and workforce as well or that Company C and University A are mistaken – perhaps customers will realize the challenges with AM designs and demand design services as well.

**Partnerships to drive the AM market forward**

All companies and the universities believe that partnerships and collaborations are important to drive the AM market forward. This instead of each company doing everything by themselves. As indicated in chapter 5.1 *Analysis of value proposition empirics*, the demand is low and immature and therefore, companies coming together and pushing the demand would be good for all actors. Company E even believes that collaborations are the only way forward for Swedish companies. Creating a critical mass to enable the development of the market is extremely important, according to both Company B and the universities:

“If we would just sit in the same room, we would solve the problems.”

(Sales Manager at Company B, 2018)

A problem with this however, according to University B, is that companies are currently not so willing to discuss their work on AM openly which makes open collaborations difficult, even if it would be beneficial:

“In all technologies, when you work together, you multiply forces. Everyone can make money on that. If you have an end-customer who understands how AM works, and sub-suppliers who are able to supply products based on the requirements of the company, it makes the market grow much faster.”

(Research Director, 2018)

While University B believes, open collaboration would be beneficial, Company D states that complete openness is nothing they believe in. Company B on the other hand brings up that they are very open to collaborations and that the partnerships they are involved in are their biggest success factors. Company C adds that companies at the same time need to be careful about partnerships downstream in the supply chain to not start competing with customers.

As Company A, C, E and F states, companies can for example collaborate to cover the value chain, or do development projects together, perhaps with more experienced companies which have come a long way in a certain area of the market. A benefit with this, which is brought up by Company D and E, is the possibility of sharing development costs since it is not always cost effective for companies to do everything by themselves; such as for all companies to develop material in-house, as exemplified by Company F.
Company A believe that since the AM market is highly dynamic, it will require new ways of structuring networks and partnerships, for example by creating alliances and platforms. Creating platforms where different actors can build and connect is also something that d’Aveni (2015) believe will become successful. However, Company D and F stress that they do not want to collaborate with direct competitors. Adding to this, partnerships do not only have to be with other companies, but also as argued Company B, C, D, F and the universities, they can be with universities and institutions, with the same purpose of driving the market forward. Strategic partnerships and alliances both with competitors and with non-competitors are different types of possible partnerships which are also brought up by Osterwalder and Pigneur (2010) who argue that this can help companies to optimize their business models and reduce risks. So, in general it can be identified that companies are open for, and sees the benefits of, having different types of partnerships to help grow the AM market faster, to learn from each other and/or to complement their value chain.

Alignment of common themes: Value creation

Regarding value creation, the most discussed themes includes start to build knowledge in a technology niche and then expand into new technologies, investing in machines to learn AM, collaborate to drive the market forward and to complement the value chain and changing the mindset of the designers to think more in AM terms. None of these themes are argued to contradict each other; investing to learn AM in a niche and then expand when suitable, while collaborating with other actors and educating the workforce about AM, is possible simultaneously. Hence, the themes could be combined to shape the value creation category of an AM business model.

5.3 Analysis of value capture empirics

The identified common themes regarding value capture are: a shift in power, close customer relations, it is a race to the market. The themes are further elaborated below.

A shift in power

Company A, B, D and E believe that companies providing end-to-end solutions will hold an attractive position. For example, Company A argue for this by saying that companies lose control if they use suppliers for some parts of the value chain. At the same time, University B, Company C, D and E believe that the power will shift towards material suppliers. University B says that the reason is that material suppliers will likely become developers of process parameters and Company C argue that it is because the material suppliers will decide the price on one of the core components of AM. However, both Company C and Company A have identified the risk of new entrants pushing the material prices and therefore, Company A still sees challenges for material suppliers if they do not have patented processes. The reason Company D believes that material suppliers will have increased power is because customers
will probably go straight to material suppliers instead of through machine manufacturers. Further, Company D believe that machine manufacturers are currently the most powerful actors and that they will remain having power simultaneously with material suppliers. University B have the same reasoning; that machine manufacturers will continue to play an important role for a while to develop process parameters, but that this will shift to material suppliers (and thereby, there will also be a power shift). Company A and C also sees machine manufacturers as the ones that are currently affecting the market the most. However, Company C is under the impression that the machine manufacturers are not making a lot of money. Company B also believe machine manufacturers will have reduced power in the future and Company E states that it would not be a good strategy to focus on machine manufacturing.

Building on the foregoing discussion, University B and Company B, C and E believe that the companies developing and providing process parameters will have the most attractive offering. As previously mentioned, University B believes that this will be done by material suppliers. Company C says that:

“The company that becomes the best in combining materials and different AM technologies to enable exactly what the customer requires – that company will be able to control their profit margin very well.”

(Board Member, 2018)

The positions or offerings mentioned in this analysis as the most powerful in the value chain are the ones that most interviewees bring up during the interviews. One area which is not brought up in the interviews as a success factor, but which is mentioned as powerful in theories, are digital platforms on which companies can build and connect. According to d’Aveni (2015), many believe that digital platforms will be the future of AM and that being a developer of such platforms should be the aim for many actors. This since operating in the center of a great amount of industrial transactions will be a highly powerful position.

The reason why platforms might become important for AM is that productions is argued to become less important, as predicted by Company C and E. Another argument is that digital designs will be hard to protect along with the potential rise of printer farms (d’Aveni, 2015). However, even if digital platforms are predicted to be the future of AM, they seem to be mainly in a long-term scenario as they are not mentioned by any of the interviewees, thus indicating that they were not on top of the interviewees’ minds when discussing AM business models.

Close customer relations
Working with close customer relations to capture value is brought up by University B and Company A, C, D, E and F. Close customer relations are argued to be preferred compared to for example targeting temporary customers who are looking
for low prices, as the General Manager at Company C expresses it. Company A believes that close relations throughout development projects will be important for companies to learn and build more knowledge. Hao et al. (2014) also argues that the relations between customers and suppliers are required to be more collaborative for AM to deliver its full potential. Company E believes that the best way is to start working case by case with customers to prove the added values that the company can offer. The Group Manager at Company E believes that companies should engage in strategic partnerships with customers where “you promise to never reveal any information [...] and you of course have non-disclosure agreements.”. This is something that the Board Member at Company C thinks the opposite of; he believes that collaborations and development projects with customers are desirable as long as they do not limit the companies in helping other customers by not being allowed to share what they have learned. Company A, E, F, the CEO at Company B and University A believe that companies should engage in development projects with customers. This is also aligned with Teece (2017) who states that a good business model design requires deep knowledge in customer needs. Company D and the Sales Manager at Company B are more skeptical towards engaging in development projects at an early stage since they believe that customers do not want to pay their suppliers to learn. Therefore, in case a company still does it, it must be significantly more skilled than the customer.

*It is a race to the market*

Company B, E and F state that it currently is a race to the market, meaning that companies are eager to enter the market to show that they exist. Mitchell (1991), argues that industry incumbents are mainly affected by other incumbents when entering new markets, while newcomers are influenced by all entrants (Mitchell, 1991; Teece, 2007). Still, the views on whether companies should hurry to the market before having a fully developed offer differ. University A and Company A, E, F and the CEO of Company B believes that companies should not spend too much time on developing the “perfect” offering and then launch it, but instead engage in development projects with customers to learn together with them. University B believes that the offering should be fully developed before approaching customers but that companies still should engage in iterative development projects with customers. As previously stated, University A also believes companies should engage in development projects with customers since it often is impossible for companies to develop an offering without strong customer engagement.

This indicates that companies should aim for close customer relations to develop offerings that meets customer demands and also that companies should help customers approach AM by engaging in close development projects while making sure that they have enough knowledge to be trustworthy.
**Alignment of common themes: Value capture**

Regarding value capture, the most discussed themes includes aiming for close customer relations, having development projects with customers and that the most powerful position will be held by companies providing end-to-end solutions, materials or process parameters. As these offerings can be argued to be better developed with input from customers, the different themes are not argued to contradict each other, but instead they are viewed as supporting each other.

### 5.4 Alignment of common themes

Combining all three business model categories leads to the possibility of combing targeting a broad range of external customers while excelling in few technology niches. This can be considered contradictory, as focusing on few technology niches is likely to limit the customers focus, and vice versa. Literature states that identifying customer segments to focus on is critical to ensure business model viability (Teece, 2017). As these themes (broad customer focus and initially starting in a niche) are not aligned with each other nor with literature, having a too broad customer focus can be argued to be questionable and as something that companies need to revise. Similarly, the themes in the value proposition were argued to somehow contradict each other, since offering AM knowledge can be considered difficult when targeting a broad range of customers, if the knowledge thereby needs to cover many technologies to serve various demands and requirements. Also, combining a broad customer focus with the themes close relations and development projects from the value capture category might be more difficult than targeting a customer niche, since the company similarly needs to develop knowledge in many areas to be able to be seen as a credible partner in these relations.
6

Discussion and conclusions

This chapter concludes the research questions and thereafter provides a discussion of the fulfillment of the research purpose. This is followed by a discussion of sustainability and ends with recommendations for future research. Thereby, this chapter provides the final marks to the study.

6.1 Conclusion of research questions

The purpose of this study is to identify how large incumbent manufacturing companies can face the evolvement of the AM market and which the common themes are in how such companies generally reason about AM business models. The research questions formulated to reach the research purpose are:

RQ1: What are the common themes in proposed AM business models among large incumbent manufacturing companies?

RQ2: How are the common themes in the proposed AM business models aligned?

The purpose is not to investigate how the case companies have structured their AM business models, but how they generally reason about the topic. To present the identified common themes, the components of business model are clustered into three categories: value proposition, value creation and value capture. The statements from the empirics are also divided into more general categories which outline the common themes. Thus, the themes sometimes work as “umbrellas” for several statements. The identified common themes for each category are summarized and presented below, followed by a discussion regarding the second research question.

6.1.1 Common themes: value proposition

The common themes concerning the value proposition category of the business model are summarized below and illustrated in figure 6.1.

- Immature demand – In discussions regarding demands, it becomes evident that the AM market is immature and that customers do not express an explicit need for AM but instead demand functions which can be enabled through AM, examples of such can be reduced weight or lead times. Another finding is that the customers having actual demands for AM mainly demand AM knowledge.
- **Internal cases as a starting point** – Several interviewees argue that an appropriate starting point for AM initiatives are internal cases. This would help companies to build up both knowledge and credibility for when approaching an external market.

- **Knowledge offerings** – Building on the identified immature demand, knowledge-related offerings are the offerings most frequently mentioned by the interviewees as potentially attractive to customers. Examples of knowledge offerings are guiding customers through the AM value chain, thus providing customers with end-to-end solutions, and developing process parameters for customers to help them achieve a successful end-result.

- **End-to-end solutions** – Closely connected to end-to-end solutions as a potentially attractive offering is the common suggestion by the interviewees that companies should try to cover as much of the value chain as possible with their offerings. However, this can be done either through partnerships and collaborations with other actors, or in-house if the company is capable of it. Covering the whole chain in-house is something that few companies are capable of and this should not be viewed as a must-do.

- **Broad customer focus** – Several interviewees argue for a broad customer focus, thus not defining a clear target audience for the offerings. This is a statement which is contradicted by theory, which instead states that the identification of target customer segments is a critical part of the business model since it helps to define the offering. Despite the interviewees being positive to having an open mind and broad focus when targeting customers, the theme is pictured in yellow in figure 6.1 due to the opposing recommendation from theory. According to the statements made by the interviewees, it seems that it is not yet clear which customers are interested of, or attractive for, AM offerings. This in turn indicates a high market immaturity, something that has also been evident in other themes.

### COMMON THEMES: VALUE PROPOSITION

<table>
<thead>
<tr>
<th>WHAT IS THE CURRENT DEMAND?</th>
<th>WHAT SHOULD THE OFFERING BE?</th>
<th>WHERE TO OPERATE IN THE VALUE CHAIN?</th>
<th>WHO TO TARGET?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved performance/functionalities</td>
<td>Knowledge offerings</td>
<td>End-to-end solutions</td>
<td>Internal cases as a starting point</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td>Broad customer focus</td>
</tr>
</tbody>
</table>

**Figure 6.1.** The common themes identified in discussions regarding value proposition.
6.1.2 Common themes: value creation

The common themes concerning the value creation category of the business model are summarized below and illustrated in figure 6.2.

- *Start in a technology niche, then expand* – Whether companies should build knowledge within a niche technology or have a broad focus has been discussed by all companies and universities. The common themes that are identified are that it can be beneficial to start in a niche technology and then, depending on the company’s strategy and ambition, expand into other technologies to build more AM knowledge. Building AM knowledge is something that all companies and universities believe is important to do.

- *Invest in machines to learn AM* – Most companies and both universities believe it is reasonable for companies to invest in AM machines for several reasons. However, the possibility of doing so does depend on each company’s specific capabilities and ambitions. An option to investing in machines is leasing.

- *Change in designer mindset required* – The findings indicate that a common internal challenge with AM is to change the mindset of the current workforce to not only focus on traditional manufacturing technologies but also consider AM as an option. Thus, companies should make efforts to educate their workforce in AM. A change in mindset is likely to be required among customers’ designers and workforce as well since it is possible that customers will manage the component design themselves in the future.

- *Partnerships to drive the AM market forward* – In general, the interviewees are positive towards having different types of partnerships to support a faster growth of the AM market. It is suggested that companies should explore different types of partnerships with the purpose of learning from each other and/or to complement their value chains.

<table>
<thead>
<tr>
<th>COMMON THEMES: VALUE CREATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THOUGHTS ON CORE ASSETS?</strong></td>
</tr>
<tr>
<td>Invest in machines to learn AM</td>
</tr>
<tr>
<td>After learning one technology, expand to broader focus</td>
</tr>
<tr>
<td>Start in a technology niche, then expand</td>
</tr>
</tbody>
</table>

*Figure 6.2. The common themes identified in discussions regarding value creation.*
6.1.3 Common themes: value capture

The common themes concerning the value capture category of the business model are summarized below and illustrated in figure 6.3.

- **A shift in power** – The findings indicate that the ones currently have the most power to affect the market are the machine manufacturers. However, the findings also indicate that it will shift to material suppliers, end-to-end solutions providers and/or process parameters suppliers.

- **Close customer relations** – Companies should aim for close customer relations to develop offerings that meets customer demands. They should also help customers approach AM by engaging in close development project, if they have enough knowledge to be seen as a credible partner.

- **It is a race to the market** – Companies are entering the market at an early stage to show that they exist, even though the market is still immature and the demand from customers is small. This indicates a race to the market for companies to already now be visible in the market and create awareness among customers.

![Figure 6.3. The common themes identified in discussions regarding value capture.](image)

6.1.4 Alignment of common themes

When investigating the alignment of the common themes, *having a broad customer focus* appears to contradict several other themes, which makes it questionable to include in an AM business model. However, excluding this theme, the remaining common themes from all three business model categories can be combined and outlined in alignment with a company’s strategy into a potentially appropriate AM business model, as displayed in figure 6.4.
6.2 Fulfilment of research purpose

By answering the research questions, we argue that the study has reached its purpose of investigating how large incumbent manufacturing companies can face the evolvement of the AM market and which the common themes are in how such companies generally reason about AM business models. Six prominent Swedish AM companies and two AM researchers have been interviewed and their answers have been presented both per company, to increase transparency and give deeper insight into how they reason, and combined under three categories, to provide a comprehensive analysis and conclusion. The findings demonstrate that the opinions regarding AM business models somewhat differ, but that certain areas of common themes still can be found. The finding also illustrates that all common themes except one are possible to combine to outline an AM business model.

Presented in this report are the combined thoughts of industry experts which provide signals of is important to think about to succeed in the AM market. However, while science and analysis are important in a good business model design, intuition is by Teece (2017) considered equally important, indicating that these results should work as guidelines for companies rather than strict must-do’s. Also, the level of certitude and confidence in answers also differ among the interviewees and it of importance to have in mind that even experts can be wrong in their predictions about the future:

“It is important to understand how the technology has evolved; against the expectations of many experts. It is important to keep in the view that sometimes a technology is so disruptive that even the experts cannot forecast what is going to happen in 10 years. And I think that is exactly what is happening in the case of this technology.”

(Professor from University A, 2018)
6.3 Discussion on sustainability

Sustainability is commonly discussed from three viewpoints: environmental, social and economic (Gibson, 2006). Even though this study does not have a focus on sustainability per se, the findings still indicate that sustainability implications (from all perspectives) are some of the important drivers for AM.

The benefits of AM are often, intentionally or not, also typical examples of necessary changes required to achieve increased environmental sustainability. For example, AM allows for a reduced use of materials and more optimized component design which can lead to higher performing end-products (Atzeni & Salmi, 2012; Bacchetti et al., 2016; Conner et al., 2014) and less waste. The interviewees in this study are rarely mentioning direct sustainability benefits but indirectly touch upon the subject when discussing, for example, demands for complex structures and improved performance of current offerings. The exception is the Group Manager at Company E who mention reduced greenhouse gas emissions from production as a benefit with AM.

More, AM is argued by some to allow for production at, or close to, customers’ geographical locations, which would in turn lead to less transportation (Ber-Ner & Siemsen, 2017). However, statements from Company A and Company E indicate that this expectation on AM is exaggerated. This is also supported by some literature: Mendonca et al. (2017) is skeptical that the scenario of local production will become reality. Thus, AM is likely to bring advantages related to environmental sustainability, but the width of those advantages is yet to be seen.

Further, at the maturity stage where AM is today, it mainly acts as a cost driver for companies and cannot yet be argued as an enabler of economic sustainability. However, it is evident that one of the future aims of AM is that it will lead to reduced costs and contribute to increased economic sustainability, for example by reducing material use and possibly also transportation distances. However, the Group Manager at Company E calls AM “the revenge of the high-cost country”, meaning that even though AM machines might not be placed at every customer location, AM will still allow companies to bring back some of their production from low-cost countries. This statement implies that even though such solutions might offer benefits for companies, it might affect the economy of low-cost countries negatively and thus lead to decreased global economic sustainability. However, this impact depends on the future growth of AM, which at this point is hard to predict.

Another perspective on the economics of AM is that the empirical findings indicate that AM offers new benefits compared to traditional manufacturing technologies – benefits which over time might lead to reduced costs but which are not included in traditional cost calculations. Therefore, cost calculations for AM might require different outlines in order to provide fair cost comparisons relative to traditional manufacturing technologies.
Regarding social sustainability, the views on the potential of AM can be argued to work as divider of groups within companies and organizations, where some are convinced that AM is revolutionary while others are highly skeptical. Therefore, in order for companies accept AM as an alternative to traditional manufacturing technologies, investments in education of the workforce and the creation of a sense of ownership are two important aspects to take into consideration. This also includes having close customer relations to manage expectations.

6.4 Future research

Based on the scope of this study and its findings, two suggestions of future research have been identified:

- This study investigates AM business models from the perspective of AM companies which primarily view themselves as providers of AM products or services. Since the customer demand from this viewpoint is considered to be low and immature, a similar study from a customer viewpoint could help to identify the demand more precisely and help to understand the barriers for customers to approach AM.

- Even though pricing models are common components of business models, they are not included in this study. This since pricing models require more precisely defined offerings. Thus, the offering must be set before a pricing model can be developed, which was not possible in this study due to its general approach. However, the question of how to generate revenue on AM offerings is still interesting and relevant and therefore, in-depth studies focusing on revenue and cost models for specific cases, where the offerings are more crystallized, are suggestions of future research. Further, since AM is more of a digital manufacturing technology as compared to traditional manufacturing technologies, such a study could include benchmarking from other industries having experienced increased digitization (for example the music industry) and how this has changed how their offerings are brought to the market.

- More, since the study is conducted from a business model perspective, it also has a managerial focus. Therefore, a majority of the interviewees who have been chosen as contributors to the study hold senior managerial positions within their respective AM initiatives/companies. However, there might be a gap between managerial expectations and technical feasibility and therefore, further technical input might be required to get a completely accurate picture of what AM can offer to companies.
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Peer reviewed journals


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**Pre-study interviews**


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