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Analysis of Business Models in Industrial Enterprises producing Discrete Goods for the B2B Sector

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Danksagung

Ich danke hiermit vor allem meinem Betreuer Andreas Schumacher der mich während der gesamten Arbeit unterstütz hat. Durch die enge zusammen Arbeit und kritisches Hinterfragen haben sich mir immer wieder neue Perspektiven ergeben. Natürlich möchte ich auch meinen Eltern danken die mir mein Studium erst ermöglicht haben. Selina Rümmele möchte ich für die vielen Runden Korrekturlesen und die vielen Gespräche über Business Modelle und Additive Fertigung danken.

Kurzfassung

Die vierte industrielle Revolution bringt eine Vielzahl an neuen Technologien wie netzwerkverbundene oder autonome Maschinen, die eine große Anzahl an neuen Möglichkeiten mit sich bringen. Eine dieser neuen Technologien ist die Additive Fertigung. Additive Fertigung ist die industrielle Anwendung dessen, was gemeinhin als 3D Druck bezeichnet wird. Wie der Name vermuten lässt werden dabei Produkte hergestellt in dem Material hinzugefügt wird anstatt durch Entfernung von Material von einem Rohling, wie bei den meisten traditionellen Produktionsmethoden.
Die Technologie des additiven Fertigens hält viele Möglichkeiten, bringt aber auch einige Herausforderungen für produzierende Unternehmen mit. Sie hat das Potential die Wertschöpfungskette fundamental zu verändern. Diese Veränderung führt dazu, dass sich Geschäftsmodelle grundlegend ändern. Das richtige Geschäftsmodell zu finden um die Unternehmensstrategie mit den operativen Tätigkeiten zu verbinden wird für Unternehmen einer der entscheidenden Erfolgsfaktoren sein in diesen schnelllebigen Zeiten. Um als Unternehmen im Business-to-Business (B2B) erfolgreich zu sein, braucht es ein gutes Geschäftsmodell. Um das passende Modell finden zu können, muss man diese zunächst beschreiben können. Derzeit fehlt es an entsprechenden Tools um dies sinnvoll zu tun. Daher etabliert diese Thesis den Additive Manufacturing Business Model Generator. Ein Tool zur einfachen Identifizierung des Geschäftsmodels und Einordnung in der Wertschöpfungskette für produzierende Unternehmen.

Die Basis für den Additive Manufacturing Business Model Generator ist eine ausgiebige Literaturrecherche um alle relevanten Aspekte und deren Auswirkung auf die Geschäftsmodelle der generativen Fertigung zu sammeln. Diese Aspekte werden dann nach den neun Dimensionen des Business Model Canvas (Osterwalder, 2004) gruppiert. Dies ist sowohl für bereits in diesem Feld tätige Unternehmen wie auch solche, die es werden wollen möglich. Das Ergebnis des Additive Manufacturing Business Model Generators kann zur Orientierung und Weiterentwicklung des Geschäftsmodels verwendet werden und leistet so einen wertvollen Beitrag zum langfristigen Erfolg von Unternehmen.

Abstract

The fourth industrial revolution brings a wide range of new technologies like connected or autonomous machines that bring new opportunities for businesses with it. One of these new technologies is Additive Manufacturing (AM). Additive manufacturing is the industrial side to what most people know as 3D printing. As the name suggest it creates products by adding material instead of removing it, like in most traditional manufacturing methods. This allows new ways of producing goods as well as for new kind of products.

While the technology of additive manufacturing certainly holds a lot of opportunities it also brings some challenges for manufacturing companies. It has the potential to fundamentally shift the value chain of producing goods. This change will lead to new business models for manufacturers. Finding the right business model to connect a companies strategy with its operations will be one of the most important success factors in these turbulent times. In order to find good business models for additive manufacturing companies in the business to business (B2B) domain it is necessary to find a way to describe them first. Currently no method to describe business models is suitable for the use in this niche. Therefore, this thesis establishes the Additive Manufacturing Business Model Generator, a tool to easily identify the business model of manufacturing companies and place them in the value chain of Additive Manufacturing.

The basis for the AM Business Model Generator is an extensive literature review to find all the aspects and consequences additive manufacturing can have to business models. These aspects are grouped in the nine dimensions of the Business Model Canvas (Osterwalder, 2004). Based on the findings from the literature review a questionnaire was developed that can be used for self-assessment of a company's business model and its placement on the value chain. With the AM Business Model Generator the basic business model of a company can be quickly identified. It can be used by companies that are already in the field of AM as well as companies that aspire to enter the domain. The results of Business Model Generator can then be used by the company as orientation for further business model development. Through this it offers a valuable contribution to the long term success of a company.

1 Table of content

2 Introduction

2.1 Introduction into the subject

The timeframe between industrial revolutions is getting shorter and shorter. While the first two industrial revolutions took almost 100 years the third one took only about 40 years and we are in the middle of the fourth which could probably move even faster (Acatech, 2013). The markets are changing constantly and organizations need to adapt their business models to fit them (De Reuver et al., 2009). To make the necessary changes a company needs to understand their business model first. Surprisingly an astonishingly high number of executives is not able to clearly describe their business model with a framework (Linder and Cantrell, 2000). This lack of description is preventing organizations to communicate it with employees on all levels. If the business model is not communicated it cannot be lived by the employees of the organization. This would mean the business model is just another document without any business impact. In order to be relevant everyone in the organization needs to understand and conduct business in accordance with their business model.

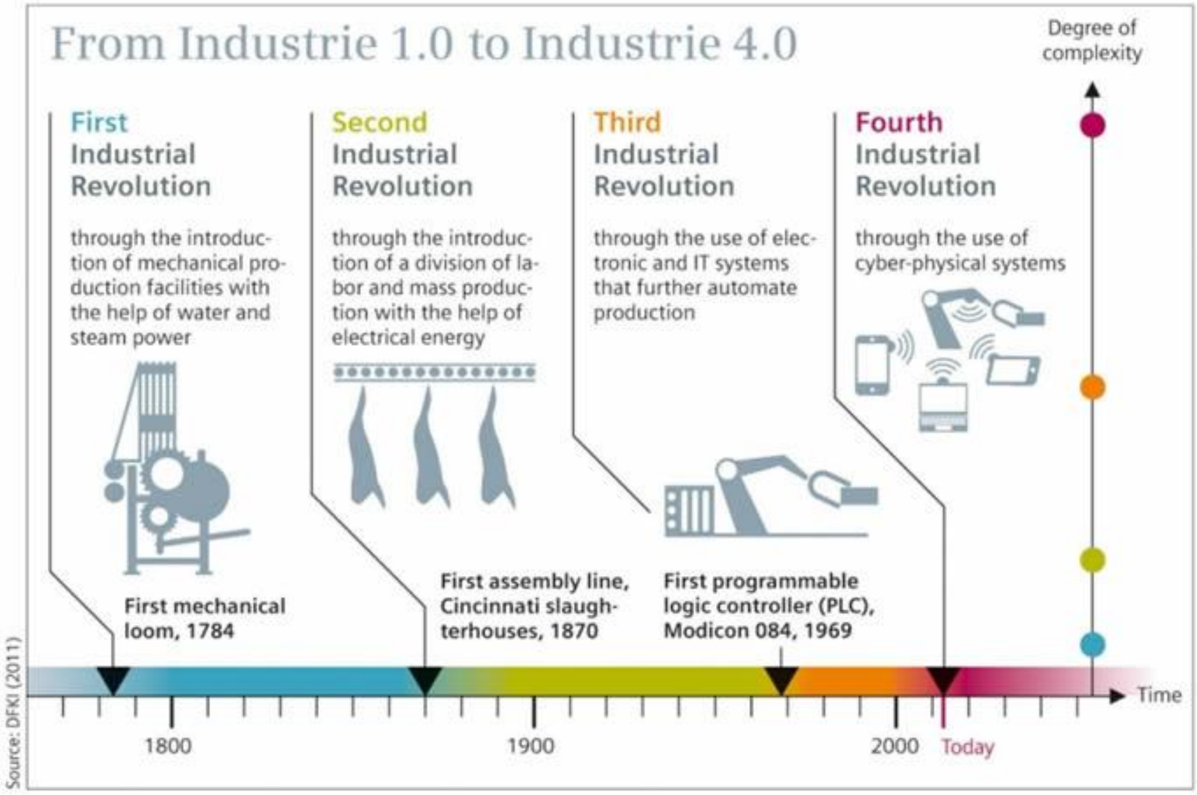


Figure 1: Cycles of innovation keep getting shorter (DFKI, 2011)

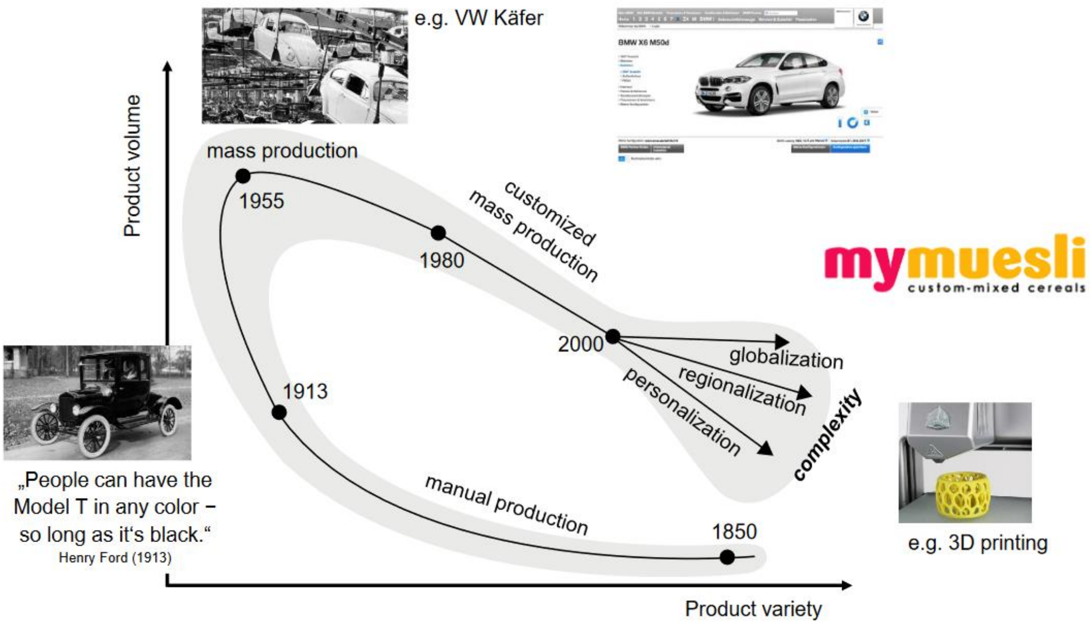


Figure 2: Complexity is taking over (Wahlster, 2011)

Literature is often overlooking the B2B industry and therefore companies lack the tools to describe their business models. A good example of the disregard for B2B business models is the book "Business Model Generator" by Osterwalder and Pigneur, one of the most popular books on the topic. In the book they describe with

their Business Model Canvas a number of business models but not one of them is of a B2B company. This lack of interest in B2B business models is puzzling especially when considering that Forrester is estimating that sales in B2B e-commerce are more than double than in B2C (Turmel, 2015).
Figure 2 is illustrating the growing complexity in the production market with growing personalization, regionalization, and globalization. 3D printing as one of many additive manufacturing (AM) methods is given as an example to deal with this environment. AM is every production method were objects are created by adding material. In contrast to traditional production methods were objects are created by removing material from the raw material. These machining methods like drilling, turning, milling etc. are called traditional production methods throughout this work.

Additive manufacturing (AM) is opening up even more possibilities for new business models. While for the next few years additive manufacturing will be still be a niche sector it keeps pushing into the mainstream and it will gain importance in B2B production (Chalabyan et al., 2017). The growing competition that accompanies the higher standing of AM will make it necessary for companies to have a clear business model. This is where this thesis wants to help by providing a tool to describe existing business models. In order to enable additive manufacturing businesses in the B2B market to find the right business model.

2.2 Research Question

This thesis is trying to answer how a framework to describe the business model of a discrete goods producing B2B additive manufacturing company needs to work. The exact question is the following:

"What is required of a framework to describe and evaluate business models of additive manufacturing companies in the B2B market?"

The question derives from a collaborative research project of the TU Wien and the Fraunhofer Austria Research GmbH. The research project is trying to answer how a successful business model has to look like for additive manufacturing in the B2B area. In order to answer this question a framework to determine existing business models needs to be in place first. Having enough different business models for evaluation is a key point to find the best ones. This is where this thesis is supposed to help. The framework developed here should help collecting business models which then in the future can be used to analyze business models of different companies.

The vast amount of information available requires researcher to be very specific with the research topic. Otherwise the volume of information in combination with a limit on time does not allow to review all the relevant literature. A well-defined research question already contains the most significant search terms for the later literature research. In this case the key word or identifiers are: framework, business model, Business-to-Business (B2B), and additive manufacturing. (Fink, 2013).

The research project from which this master thesis is inspired intends to use the here developed framework for collecting different business models in use. Through this analysis the most successful business models are meant to be found. It is important to get as many different business models from a wide array of businesses in order to do that. For this purpose, the developed framework needs to provide the following:

- **Self-Evaluation** of business should be possible fairly easy. This means by providing a simple tool with just a few information. A non-expert in business models should be able to describe the general business model of his company.
- **Orientation-Tool** to start discussions about how the business model of a successful company should look like.
- **Adaptable** to changes and specific changes of all the businesses encountered. It should be possible to use creativity techniques in combination with the developed framework.

2.3 Proposed solution

To answer the research question this thesis is trying to give the reader the necessary theoretical understanding of business models first. Then the differences between Business to Customer and Business to Customer regarding business models need to be discussed. The last theoretical topic then is additive manufacturing. After establishing a basic understanding of the topic, different frameworks to evaluate business models will be reviewed. From these different frameworks the best to describe additive manufacturing companies will be chosen. The chosen framework then will be adapted to better suit to the intended purpose. Necessary adaptations will be found by applying the framework to business models described in literature. With this method, many different business models should be found, from which general assumptions can be made. This should lead to a clear vision of a business model framework for additive manufacturing companies in the B2B sector.

The thesis is structured into three parts: theoretical basis, framework development, discussion of the result. The first part is laying out the theoretical foundation for the fundamental areas which are relevant for the topic. In the second part a review of existing frameworks will be done. The reviewed frameworks will be the basis for developing the new framework. The framework will be developed by using a scientific literature review and applying the knowledge of this review to the existing ones. In the last chapter the results and further steps will be discussed.

3 Used method: literature research

The method used in this thesis is an extensive literature research about different business model aspects. For that scientific papers and books where reviewed but also science magazines. The review is used to get a clear picture of the status quo of what the existing business model's aspects of additive manufacturing companies are. In order to do the literature review in a scientific way an adaptation of the Research Literature Review after Fink (2013) will be applied.

Figure 3: Adaptation of Research Literature Review after Fink (2013)

The first step is formulating the research question. The process of finding the question was already discussed in an earlier chapter (2.2 Research Question). The research question is: "What is required of a framework to describe and evaluate business models of industrial companies in the B2B market?". After the decision about the research question it is necessary to collect literature to conduct the review. For that the databases and websites which will be considered need to be selected. Since all the scientific fields (AM, BM, and B2B) are rather new it is safe to assume that most publications about it are available in digital form. For this reason, mainly online databases are used for this thesis. The collected literature is supposed to represent the current scientific standard in the field. In order to minimize bias, which certain platforms could have, a set of search platform are used. The used platforms are specifically:

- Google Scholar: Is a search engine for scholarly literature. Google is not providing data on how many articles are linked, but estimations are that they linked 100 million English-language articles. This would account for 90% of all English-language scholarly articles (Khalsa and Giles, 2014). Therefore, it will also be the main source for finding literature.
- Science Direct: Is one of the leading platforms for peer-reviewed articles.
- TU Library: Is the Library of the Technical University of Vienna
- Google: Since the literature review is about finding current applications of business models, professional magazines like Harvard Business Review or Metal Additive Manufacturing are also considered. Google appears to be the best way to find articles in such magazines related to Additive Manufacturing.

After selecting the databases in which the research will be conducted the specific search terms need to be defined. Combinations and of relevant search terms and the usage of special search functions can help to reduce the huge amount of literature found. The search for “business model canvas and additive manufacturing” is returning 616.000 results on google.com. The combination of the terms as fixed search terms as ““business model canvas” AND “additive manufacturing is reducing the number to 12.700. While this number is of results is still too large to look through the combination is also significantly increasing the relevance of the found articles.

After the search terms are defined the search can be conducted. While doing the search it is helpful to have some practical filters in place to minimize the amount of literature and ensure the relevance of it. The most obvious filters are language and date of publication. Literature written in English will be the main source, but German written ones will also be considered.

The research areas are all rather new and are still constantly developing. This is especially true for additive manufacturing. Figure 4 shows the development of 3D Printing patents over the last 70. With more than half of all patents dating 2010 or after it is obvious that there is a lot of development going on years (*3D Printing Technology Insight Report*, 2014). Because of all these new developments only literature published from 2010 onwards will be considered regarding additive manufacturing.

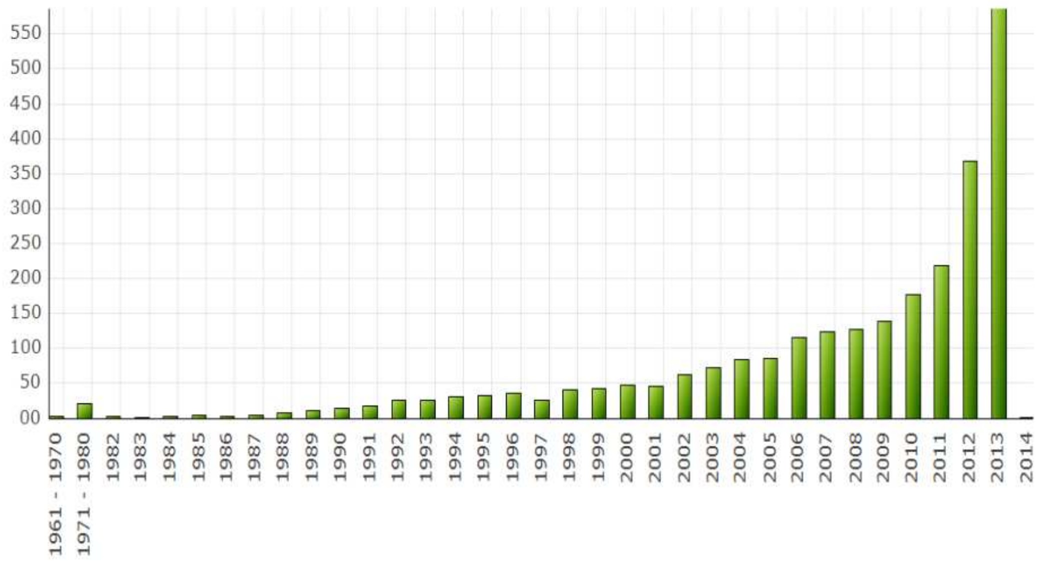


Figure 4: Number of 3D-Printing patents by year (*3D Printing Technology Insight Report*, 2014)

The other two fields, Business Models and B2B, are also rather new and still developing for these reasons there will be no strict publishing date restriction. Nonetheless the focus here is clearly also on literature that was published rather recent. This means that literature published after 2000 is preferred.

The last step in a literature review is synthesizing the reviewed material. Synthesizing is fulfilling four main purposes: First it gives an overview of the current knowledge of the research topics. Second it establishes the need for further research in the area. Third it describes what the findings of the research is and fourth it describes the quality of the body of research. (Fink, 2013)

4 Theoretical Basis

This chapter is laying out the basics of the topics addressed which is necessary for understanding the problem and finding a solution. For this a look at three main areas of this thesis is necessary. The first area of focus is the foundations of business models. Next is the difference between businesses in customer and business facing areas. At last the specifics of additive manufacturing will be outlined.

4.1 Business Model

The internet changed the way how business is conducted in significant ways. It allows new ways of distributing goods and services that are challenging the existing business models. Especially traditional companies need to rethink their distribution strategy (Teece, 2010). This increase in speed and complexity opened up a gap between the business strategy and business processes. Business models are helping to close that gap (Al-Debei et al., 2008).

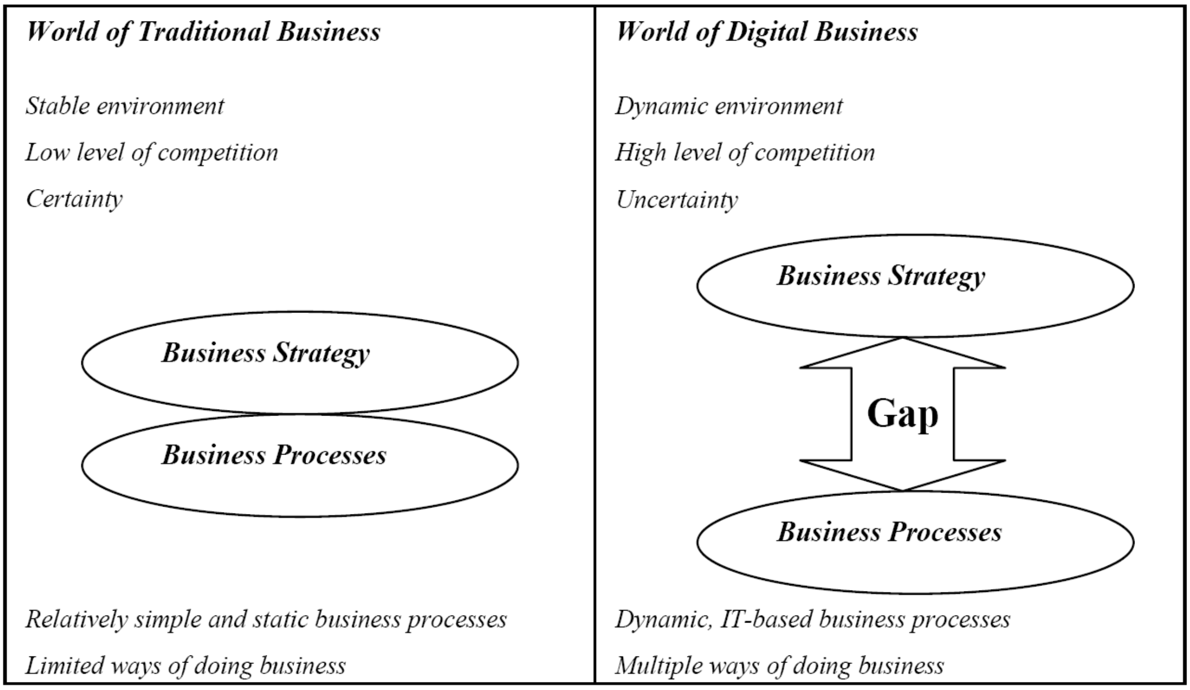


Figure 5: Traditional vs New Business World (Al-Debei et al., 2008)

There are different definitions of business models and none is clearly accepted by all researchers and practitioners (Morris et al., 2005). The lack of a clear understanding makes it difficult to discuss the topic. The existing dissent can be seen with the distinction from strategy. As an example, Teece (2010) is arguing that business models are much more general than a strategy. While others like Osterwald (2004) or Magretta (2002) put the business model beneath strategy. This lack of common understanding makes it necessary to first outline the understanding of business models as used in this paper.

Besides helping businesses navigate the new economic reality that the internet brought business models are helping to transfer economic theory into business reality, e.g.: In the traditional economic theory it is often assumed if value is created a customer will pay good money for it. In dogmatic economics, the price will be paid if the utility is higher than the price so there is no need for designing a business model in order to capture the value. This model clearly has problems to describe the real world, where contrary to theory markets are not always available, transfer of knowledge is not free, and no innovation takes place. In a perfect world as described in the textbooks there would be no need for business models. In reality business model are needed to translate the created value into sales by for example finding the right way to distribute it to interested groups of customers. (Teece, 2010)

4.1.1 Business Model definition

Probably the most common misperception about business models is that they only describe the way a company generates revenue (Linder and Cantrell, 2000). While the revenue model is certainly an important part of the business model, it is far from the only characteristic. Osterwalder (2004) is considered as one of the most influential researcher in the field of business models. He sums business models up in the following way:

> *"A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams."*

These two sentences contain a lot of information that need more explanation for understanding business models in its fullest. Let us look at the single parts of these sentences. First a business model is established as a tool. This tool helps to make the implicit logics of how a company earns money explicitly. Making things concrete is a key technique when trying to make people remember something (Heath and Heath, 2008). Employees that remember how the company is making its money are probably going to make decision more aligned to these ways than employees who do not (Osterwalder, 2004). Business models are a way of communicating and getting employees on the same page. This makes business models an important tool of strategic management because it helps to transport the core values of the company.

The second sentence starts with the idea that a business model is describing how value is generated and delivered to certain segments of customers. An important part here is choosing the customer to whom the value is delivered. Knowing the customer is just as important as the value the product delivers itself, since no company can survive without customers (Osterwalder and Pigneur, 2010).

A good example for that is Google Glass. Described in short Google Glass are glasses equipped with a camera that can show information of looked at objects in real time. When first introduced back in 2012 it was pushed as a device for private everyday use (Levy, 2012). After the public outcry over privacy issues and a lack of useful applications it disappeared quickly from public availability. The quick disappearance from stores allows to view Google Glass as a failure. But Google has shifted its focus away from end customers to business customers it seems that Google Glass will become successful after all (Levy, 2017). Companies like Boeing, Volkswagen and DHL are now working with it. If companies with such high standards are using Google Glass it needs to have some value. The second "version" of Google Glass is basically delivering the same value. While there were some refinements made no innovative technology was added to the one used as a professional tool. This means that although Google produced a good product, they did not become successful because they chose the wrong target group. At the same time, it looks like they made it successful without really adding any other value to product just by changing the audience.

The last part of the second sentence mentions the importance of not just creating a revenue stream but also a sustainable one. This means that business models are not just there to create quick wins and fast money. It is an important tool to gain, sustain and increase a competitive advantage over an extended time frame. In order to sustain a competitive edge in an ever-changing environment, organizations need to change constantly as well. Companies that change in an organized way are doing better than companies that try everything new without a plan (Linder and Cantrell, 2000). This is where creating a business model helps: You need to know where you are at in order to know where you are going.

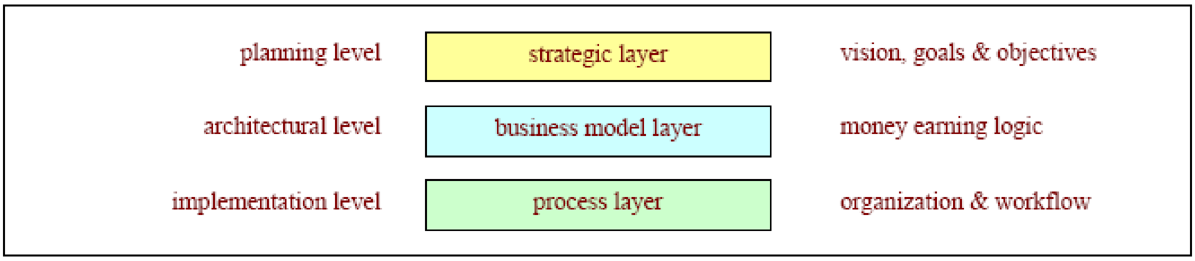


Figure 6: Business layers (Osterwalder, 2004)

Often the terms business model and strategy are used interchangeable (Magretta, 2002). This lack of clear distinction between the two concepts has kept researchers from identifying features of business models which lead to better results (Casadesus-Masanell and Ricart, 2010). Figure 6 is illustrating the order of the concepts of strategy, business model and processes in regard to abstraction. Strategy is defining where a company is heading by giving out a vision for the future and stating goals. This vision and the goals are determining in which markets the company is participating and in what way. Depending on the market the company is competing different models for earning money are necessary. These different models to earn money are the business models. The kind of business model the company will choose in order to compete in the market is then determining the kind of processes it puts in places to enact the business model (Casadesus-Masanell and Ricart, 2010). Strategy, business model and processes need to be closely aligned in order to give the organization a competitive edge that can be sustained. It is important to understand the difference of business model, processes, and business strategy (Teece, 2010). In this thesis the term business model is used in the definition of Osterwalder.

4.1.2 Describing Business Models

With the basic understanding what business models describe the question arises how it is described. For that Krumreich et al (2012) did an analysis of 34 publications on the topic. Their result was that in order to describe business models five main components with a subset of 20 categories are necessary. The main components are models to describe the following parts of a company: Value Creation, value offering, value capturing, cooperation, and financials. Every one of these models has a subset of categories. Some publications like Osterwalder (Osterwalder, 2004) have more dimensions by making categories into models and some have less by merging models.

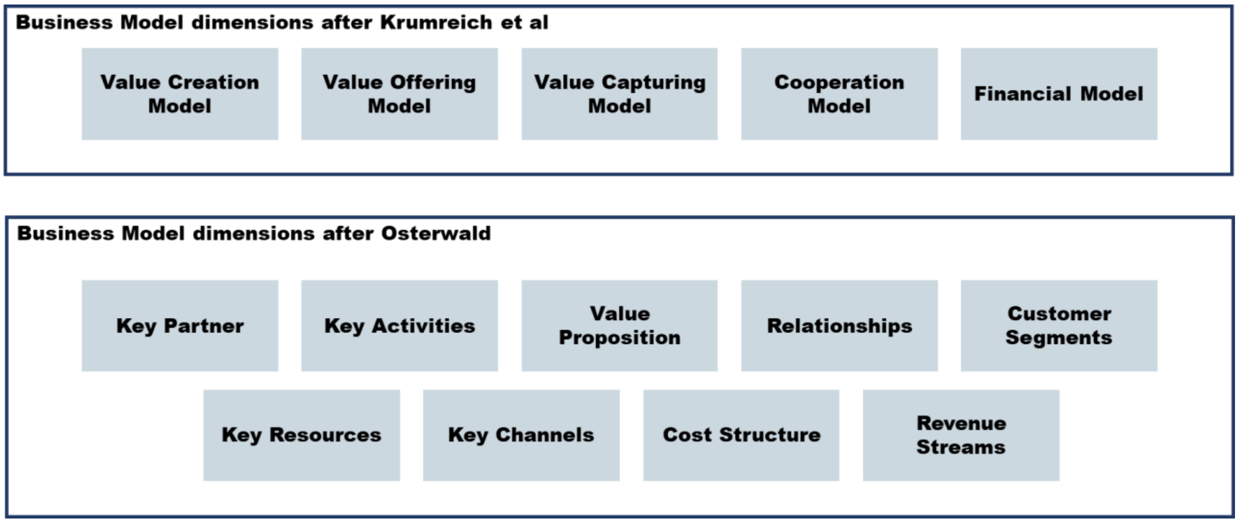


Figure 7: Dimensions of different models

Despite the different framing of the subjects these models and subcategories give a good overview of what areas business models touch. Another way of describing business models can be seen in Figure 8, (Casadesus-Masanell and Ricart, 2010). Casadesus-Mansanell und Ricarts model describes how different parts of the business model are influencing each other. There is a lot of information hidden in it. Underlined elements for example are choices that were made and non-underlined elements are consequences from those decisions. As an example, the fact that Ryanair uses a “Standardized fleet of 737s” leads to the fact that they have “Bargaining power with suppliers”. In contrast to the model from Krumreich or Osterwalder this model is not only showing the different elements of the business model but also their connection to each other.

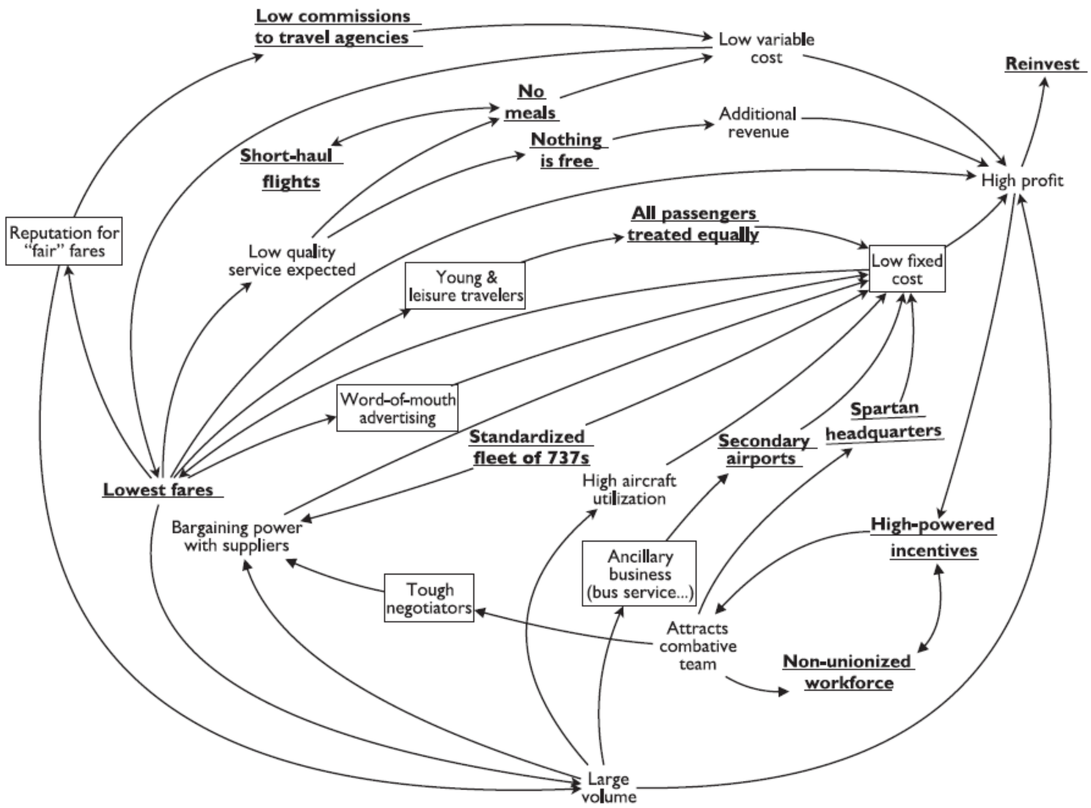


Figure 8: RyanAir Business Model (Casadesus-Masanell and Ricart, 2010)

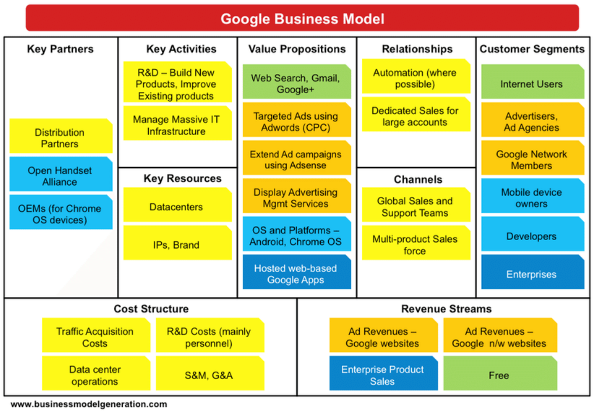
4.1.3 Competitive edge of business models

It is quite easy to find descriptions of business models from successful companies online. A quick search for "business model examples" in Google's image search immediately shows the business models of companies like Google, LinkedIn, Gillet and much more. Two of the found examples can be seen in Figure 9. None of these business models seem very hard to copy if looked on from afar. There is nothing that would block competitors to adopt the same business model if they choose to do so. This leads to the question how a business model can provide a sustainable competitive advantage. Teece (2010) is giving three reasons why a new business model can do that:

1. Implementing a business model requires systems, processes and assets which are in fact not easy to copy. Southwest Airlines pioneered the business model of a low fare airline and is now the biggest low fare airline in the world. The idea of offering flights for the lowest price possible is not complicated.

Nonetheless no other airline was able to achieve the same success as Southwest Airlines. (Morris et al., 2005)

2. Understanding the genuine business model might actually take a while and is not as clear as it seems. The business model of Gillette could easily be seen as a traditional high-quality product model, where trough selling high quality products high margins are possible. While having a quality product is surely a part of their model the more important one is the now famous “Razor & Blades” model. This model offers a relatively cheap basic product which then generates returning revenues through recurring purchases for spare parts. The same model is also known from printers where a new printer can be cheaper than buying new ink. Business models often have more than one side to it which makes it more complicated to copy them than it initially seems.
3. Organizations are not always willing to change their way of doing business. This reluctance can give a fast-moving company a decisive edge. Netflix and his then competitor Blockbuster are a great example for that. When Netflix shifted their business model and started to rent out movies via mail Blockbuster was reluctant to do the same. Blockbuster was the biggest movie rental company in the USA and had a wide network of stores to rent movies. Their strength in brick and mortar stores kept them from investing in the new distribution because they were afraid of cannibalizing their own revenue. The hesitation of Blockbuster allowed Netflix to dethrone and eventually even push them out of business.



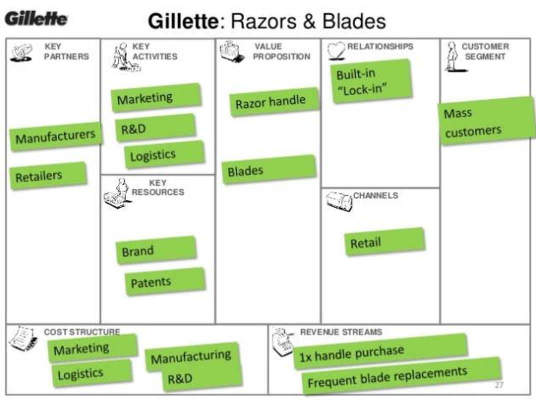


Figure 9: Example of accessible business models in the internet

As the example of Blockbuster showed, having a plan for changing environments or competition is necessary for long time viability. This is a key point that often seems to get lost. While having a clear business model is a necessity for being successful now, having a clear idea how to change your business model when changes arise is just as important. A change model helps a company to understand how to adapt their business model in order to stay competitive in an ever shifting environment. (Linder and Cantrell, 2000) In order to change the business model into the right direction an understanding of the current one is imperative.

4.1.4 Business Models summed up

Business models are an interdisciplinary topic spanning the fields of economics, organizational theory, strategic planning and marketing science (Teece, 2010). They help organizations to navigate the complex playing field of today's economy. They do that by linking the strategic with the organizational level. Business models transform the ideas of the strategy into explicit concepts. Often this includes visualization or creative tools. These concepts then give people in organizations orientation to find the right way to create processes to realize them. Business models therefore help companies being successful by aligning the processes with the strategy (Al-Debei et al., 2008).

4.2 Defining Business-to-Business

In order to get a framework that is able to describe the business model of additive manufacturing companies in the business-to-business area it is necessary to understand what B2B means. As most people have an understanding of business-to-customer (B2C) relationships from their daily experience this thesis also points out how the two concepts differ from each other.

4.2.1 Business-to-Business Basics

Business-to-Business, or B2B as it will be called in the remainder of this paper, is every transaction that happens between two or more professional organizations. B2B commerce is with more than US$8 trillion accounting for roughly half of the US gross domestic product (Wu, 2015). In the e-commerce sector it is even more significant where the global B2B market will value US$7,7 trillion compared to US$2,1 trillion of the B2C sector (Mehta and Berthelmann, 2017). Considering the size and importance of B2B it is interesting that research into B2B marketing is far less developed than into B2C (Hadjikhani and LaPlaca, 2013).

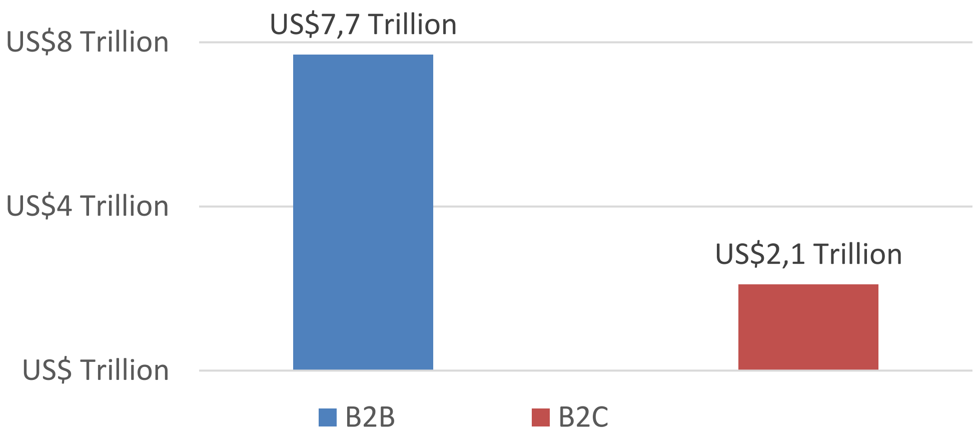


Figure 10: Global E-Commerce market value B2B vs B2C

In a B2B business deal all involved parties are professionals. The degree of information about purchased products is viewed as one of the most important differences between B2B and B2C. It is generally assumed that B2B customers have a good understanding of the products they purchase. In theory they purchase products more rational than end customers. This theoretical objectivity renders B2C ideas like brand or reputation unnecessary and purchases are solely made based on facts like functionality, service, price, and quality. While decisions in the B2B market are certainly made more deliberately a certain level of emotionality resides. This can be seen by the growing number of B2B businesses adopting brand strategies and it pays off. Figure 11 illustrates that companies with above average B2B branding recover faster from stock market crashes than the others. (Kotler et al., 2006).

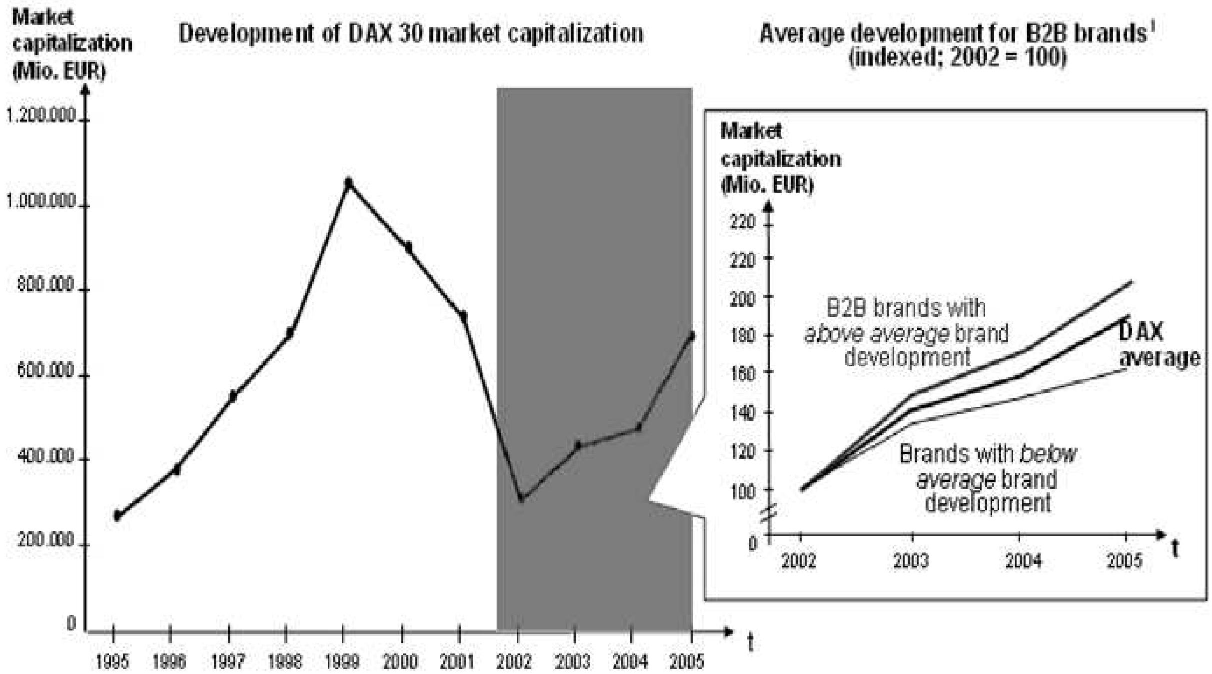


Figure 11: Good branding increases share price (Kotler et al., 2006)

This means that while there is still a difference regarding brand strategy the difference is getting smaller and more and more B2B companies start caring about their brand. This has implications for the two sourcing options available: **systematic sourcing** and **spot sourcing.** Systematic sourcing means that a special long-term contract is in place with a certain supplier. It is somehow done almost exclusively by businesses and is therefore a key indicator for B2B. These long-term contracts are leading to a special relationship between supplier and buyer. It is important for companies in the B2B market to have sales agents who could form bonds with clients. A close relationship between sales agent and procurement of customers gives a company a significant competitive edge. In spot sourcing no such relationship is formed and products are mostly bought on price criteria. (Kaplan and Sawhney, 2000).

Spot sourcing is a typical end consumer behavior. While as a consumer we tend to look for the cheapest price we all know it is not the only criteria. Most people rather buy a mobile phone from a well-known brand than the cheapest. In the last years a lot of electronic marketplaces specialized on B2B, so called eHubs or B2B platforms, have emerged. These platforms create value by aggregating buyers and sellers, creating marketplace liquidity, and reducing transaction cost (Kaplan and Sawhney, 2000). With the aggregation of buyers and sellers in one place and reduced transaction costs businesses are moving from systematic sourcing to spot sourcing.

With the emergence of B2B platforms where business consumers can easily choose from different products, brand management for B2B businesses gets more relevant.

4.2.2 Difference between B2B and B2C

The visualization below (Figure 12) is giving an overview of the key difference between the two ways of marketing. For the purpose of this paper it is not necessary to go through all of the points, but we will touch on some of the key elements that will help us understand the main differences.

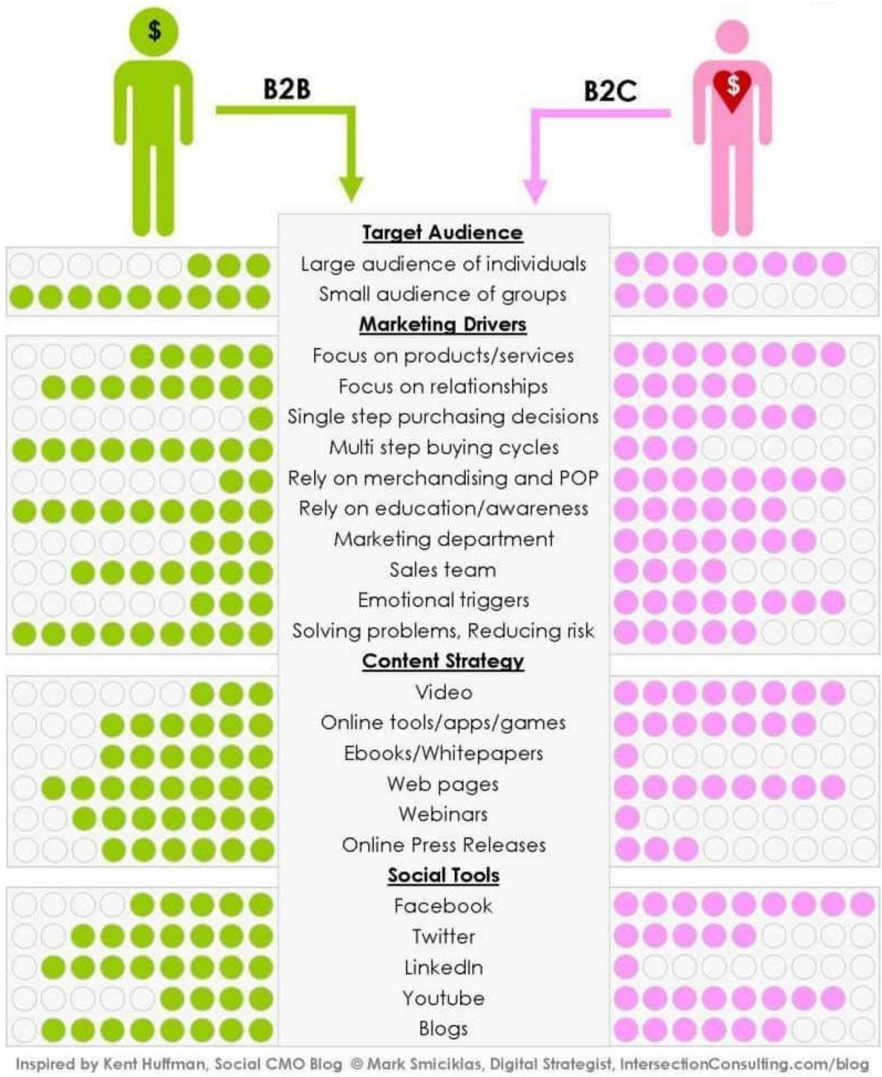


Figure 12: Visualization of the difference between B2B and B2C (Mark Smiciklas, 2010)

The first and probably most obvious difference is the size of the targeted audience. While in B2C the audience is diverse and except of some segments rather big, the audience of B2B marketing are a few people that are responsible for purchasing at certain companies. To sell products it is necessary to get the attention of these individuals. While the audience of companies to address is rather small, the group of people involved in making the purchasing decision within those companies is normally bigger than when a consumer makes a decision. This is the reason why B2B transactions often requires more time to make the purchasing decision with several instances of approval and a whole group of people being involved. In B2C the purchasing decision is mostly made by a single person and therefore highly dependent on personal emotions. In the B2B world decisions are made by different people distributed over time, this is why emotional appeals are not as effective. Therefore, B2B marketeers need to focus on educating the targeted audience and make them understand the upside of the sold product. With that in mind it makes sense why the marketing content is different. From a content perspective the main differentiators between B2B and B2C are blogs, whitepapers and webinars. These formats have a very low impact on B2C but they are major vehicles for content in B2B marketing. Blogs, whitepapers and webinars in the B2B world are often trying to answer concrete questions of the targeted purchasers and through that converting into a sale. (Hitesh Bhasin, 2018)

Another major difference beside how companies and people are buying products is the kind of products they purchase. While in the B2C markets customers are buying finished products, in the B2B area purchased products or services are inputs into other products or services themselves. These inputs can be a wide array of goods that can be classified into two categories:

- **Operating inputs**
  Inputs that are not part of the finished goods but are needed to produce them. Examples are office goods, spare parts, maintenance and airline tickets. They are not specific for certain industries. Therefore, suppliers of these goods are often serving customers across different industries. Shipping of operating inputs can mostly be done with standard general suppliers like DHL or UPS.

- **Manufacturing inputs**
  These are the raw materials that are going directly into the product or processes. They vary from industry to industry and often require special

delivery methods. Steel for example will not be delivered by a standard delivery company like DHL or UPS but with shipping experts instead (Kaplan and Sawhney, 2000).

To sum up organizations in the B2B market are mostly companies that produce inputs into other products. For these inputs price and personal relationship used to be the most important factor for buying, while brand was more or less negligible. With the emergence of B2B platforms, being a brand is growing in importance in the B2B market, and personal contact to buyers is not the sole driver of sales anymore.

4.3 Additive manufacturing

This chapter lays out where Additive Manufacturing (AM) is coming from, then shows the basic systems of additive manufacturing and the processes involved. At last the possibilities AM is providing for businesses will be discussed with its advantages and shortcomings.

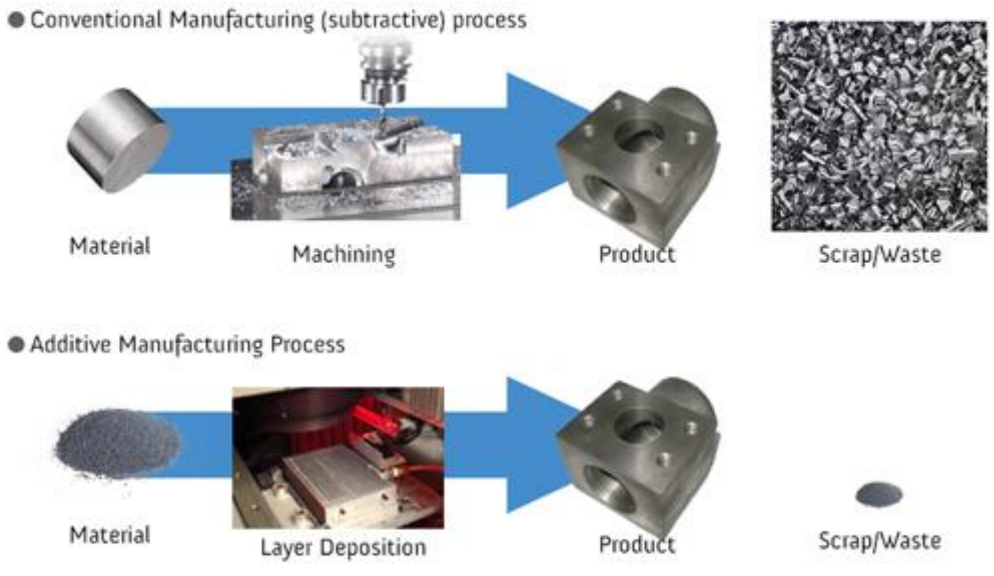


Figure 13: Conventional vs Additive Manufacturing

Additive manufacturing is the general name for production methods that are often described as 3D-printing. The key feature of it is that instead of taking material away from a structure (e.g. in milling), material is added layer based. The term 3D printing was appropriate when it was mostly done with polymers. Today with the use of metals, ceramics, composites and even biological material "additive manufacturing" is more appropriate. With all these materials available it can be used to produce false teeth, jewelry or part for cars and airplanes (The Economist, 2017a) and soon probably even organs (The Economist, 2017b). Additive manufacturing has its roots in rapid prototyping. Rapid prototyping is used to create a mock up or even better a working prototype of the planned product. This allows faster feedback on form, fit and function. By getting early feedback on those parameters development speed can be improved significantly. Technologies like 3D-printing are perfect for this purpose because they allow to create a prototype directly from the digital design. While most of the technologies in additive manufacturing have their origins in rapid prototyping they are used for much more than that today. The technology of AM is just on the verge of becoming a tool for mass production. (Gibson et al., 2010).

4.3.1 Classification of AM

Additive Manufacturing can be clustered by the input material into three distinct groups: Liquid based, Solid Based, and Powder Based. Figure 14 shows this classification and further sub classes. For the purpose of this thesis it is enough to have a high-level understanding of the three basic principles.

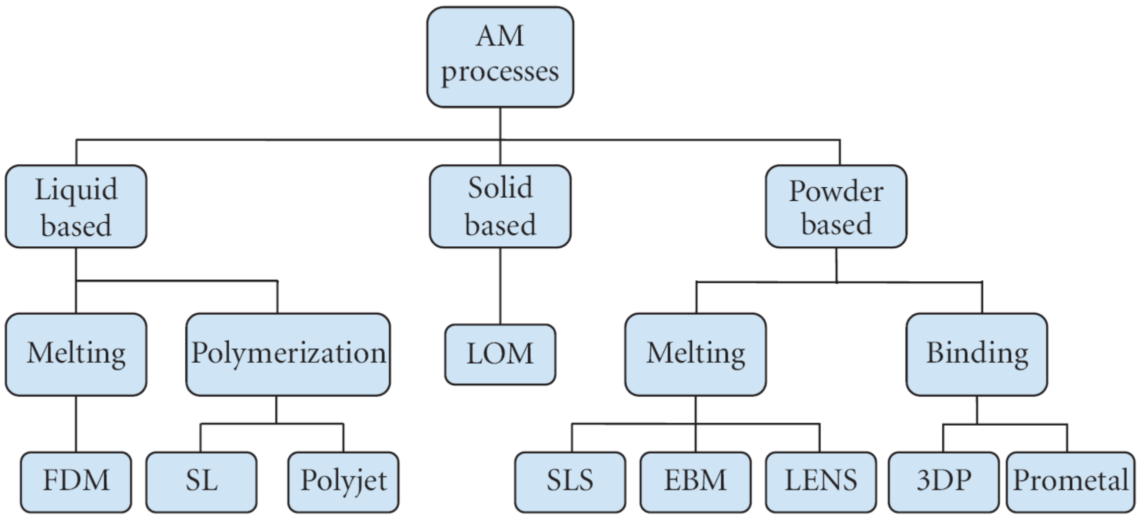


Figure 14: Classification of AM technologies (Wong and Hernandez, 2012)

Powder-based systems

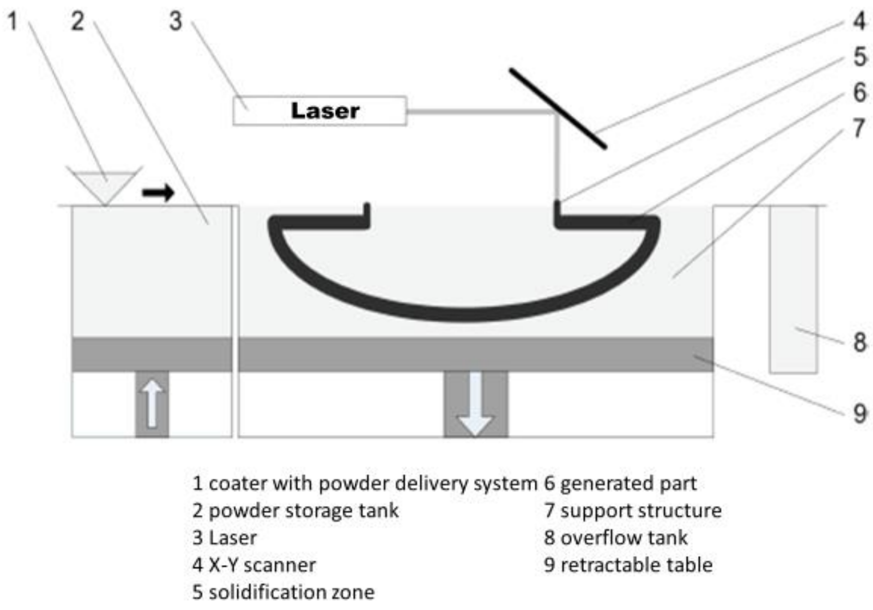


Figure 15: Basic schematics of laser beam melting (VDI 3405, 2014)

Laser beam melting as shown in Figure 15 is one of the most widely used powder-bed systems currently in use. It is also known under the trade names “Selective Laser Melting” (SLM). Laser beam melting is perfect to explain the principles of powder-bed system. First the coater is spreading a layer of the powder from the storage onto a retractable table. The layers normally have a thickness between 20 to 100 µm. Then the laser is melting they layer in the shape of the object that needs to be created. The table then retracts slightly and a new layer is applied and again melted. New systems even work with multiple lasers at the same time which increases the speed significantly. The not melted powder is acting as a support structure, which allows complex forms that would otherwise collapse. (Isaza P and Aumund-Kopp, 2014)

Solid based systems

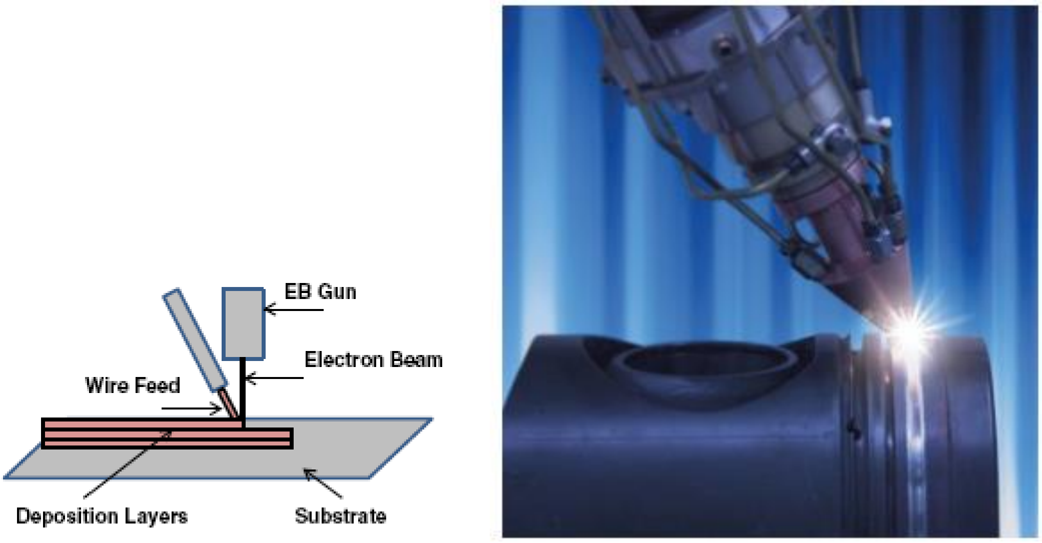


Figure 16: Wire-fed System schematics (Frazier, 2014) and Laser Cladding in action (marinfinderparts.com, 2018)

The schematics of a solid based system can be seen in Figure 16. The wire is fed into position and then melted with a laser or an electric beam. It allows for high deposition rates and therefore large volumes. The wire is basically welded onto the existing part and because of that often is called cladding. Manufacturing equipment company DMG Mori is offering laser cladding systems on a 5-axis milling system. This allows flexible application (Isaza P and Aumund-Kopp, 2014). Such flexible systems can not only be used to create a part but also to repair parts like pistons, shafts etc. (Laser Cladding Singapore Pte Ltd, 2018).

Liquid based systems

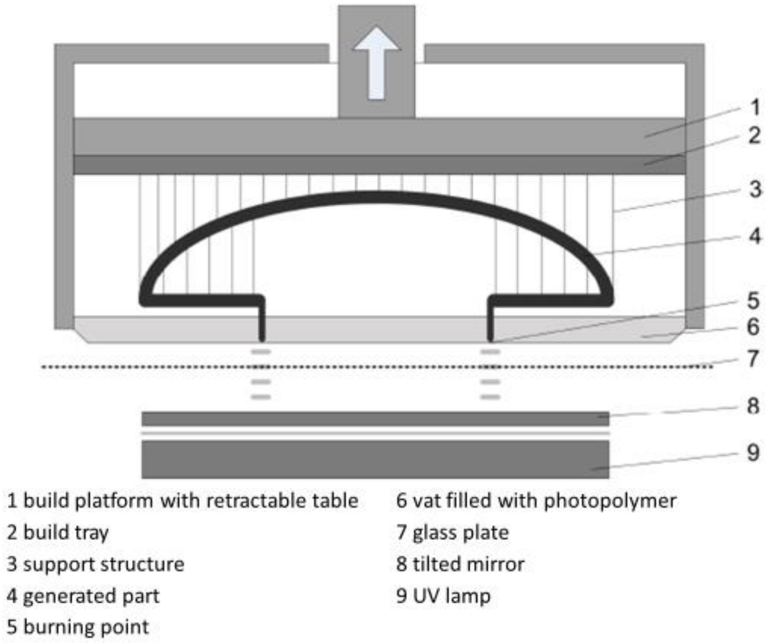


Figure 17: Liquid based system - Digital Light Processing (VDI 3405, 2014)

Liquid based systems as shown in Figure 17 use UV lasers or a familiar energy source to solidify a photo-reactive resin. The change from liquid to solid is happing layer based (Attaran, 2017). With this method the binding happens chemical in opposition to the thermal processes of powder and solid based systems. Another big difference to the other two methods is that liquid-based systems do not work with metals.

4.3.2 Process Steps of Additive Manufacturing

While they can be highly different in the used technology, most additive manufacturing processes have the following 8 steps (Gibson et al, 2010):

1. CAD (Computer Added Design)
   AM always needs a digital model of the geometry. Mostly these models are created in professional CAD software by product designers and engineers. It is also possible to get a digital model through 3D scanning but the created models through scanning often need some manual adaptations by a professional to reach the necessary standard for industrial use.
2. Conversion to STL
   STL (STereoLithography) is the standard file format used by most AM machines. Basically, STL converts the CAD-model into thin slices which can

be created and added by the machines. The slicing of CAD model is done with mathematical models which is why it requires some professional knowledge. How STL works will be discussed in more detail later in this paper.

3. Transfer to AM machine

   In this step the files are not only transferred to the machine but also adapted to a specific machine.
4. Machine setup

   Depending on the requirement of the output the machine can use different settings for layer thickness, timings, material constraints etc. The different settings have competing impact on the duration of production and the quality of the finished product.
5. Build

   In this step the machine more or less produces the part automatically. Some form of control may be appropriate.
6. Removal

   The produced part needs to be removed from the machine. This can happen manually or automated.
7. Postprocessing

   Often the product needs some form of additional cleaning or further manufacturing steps. Necessary steps can include removal of material by saw, polishing or coating the part.
8. Application

   At last the part can be used for the intended purpose.

   (Gibson et al., 2010)

This is the general process of professional additive manufacturing. There are variations, especially in the home appliance area, where parts of these steps are skipped but in general, they are necessary to produce a business grade additive manufacturing product.

4.3.3 Potential of Additive Manufacturing

Additive manufacturing has huge potential for the individualization of products. Companies like Nike and New Balance are hoping to move from mass production to customized production when needed (Fitzgerald, 2013). This is how most people know 3D-printing, as a tool for customization but there are different operating models as well. John Deere a major producer for agricultural machines hopes to decentralize spare parts production. Instead of keeping high number of parts in storage they want to save the production files online. And if a spare part is needed the file can be downloaded and printed at a local partner workshop. (The Economist, 2017a)

Additive manufacturing has also high potential in cost saving. GKN Aerospace, a British aeronautics company is trying to produce titanium parts for airplanes with additive manufacturing. This way they hope to save up to 90% on waste material. (The Economist, 2017a). Additive manufacturing can reduce waste in different ways. The first one is by reducing the material needed to produce a part. Since only the material needed for the finished part is added there is almost no excess material. This reduces the wasted material significantly. In airplane production AM could save around 4050 tons/year of Aluminum and 7600 tons/year of Titanium by 2050 while only using half the energy of traditional manufacturing (Huang et al., 2016). Huang and his fellow researchers further calculated that weight reduction for airplanes could reduce fuel consumption by as much as 6,4%.

Lowering lead time is another way of reducing waste both in the sense of lean and in the sense of actual material reduction. Lower lead times to prepare production facilities allow for smaller batch sizes. This leads to less material on shelfs that possibly will never get sold. By moving production further to on demand, less excess material is needed and therefore less waste gets produced. All three of these waste reductions can clearly be seen in the comparison of the hydraulic valves in Figure 18

Figure 18: Comparison between Traditional vs Additive Manufacturing (aidro.it, 2018)

Both valves showed in Figure 18 are produced by the Italian company aidro hydraulics. While the one on the left was manufactured with CNC machining, the one on the right was produced with the additive manufacturing technique Powder Bed Fusion. The metal 3D printed valve is about 60% lighter than the one produced with subtractive production methods. While weight is significantly reduced the functional tests with 250 bar pressure showed no substantial difference between the two. Further lead times can be significantly reduced. The AM produced part has a lead time of only 4-5 days while the traditional one has at least 30 days lead time. (aidro.it, 2018)

Until recently 3D printers were only able to print with one material at a time, which was a fundamental problem for using it in an industrial way. This also changed with the introduction of new printers that can use different material simultaneously. This allows different fabric mixes in one product and is further increasing the possibilities of 3D printing. (Rayna and Striukova, 2016)

The market for additive manufacturing is rapidly growing as shown in Figure 19. From 2014 to 2015 the AM industry grew 25,9% to $5,165 billion in total. This number includes all additive manufacturing equipment and services around the world (McCue, 2018). Reduction in costs for the technology and increased applications will lead to strong growth of the market. It is expected to exceed $21 billion by 2020

(Attaran, 2017). In their 2017 report the consulting company A.T. Kearney ranked countries according to their 3D printing leadership based on metrics like 3D printing capabilities, macroeconomics, governance etc. In their index the leader is the United States closely followed by Germany. The follow ups are South Korea, Japan, U.K., and Singapore. South Korea and Italy are the fastest growing countries in regards to 3D printing capabilities. (Monahan et al., 2017)

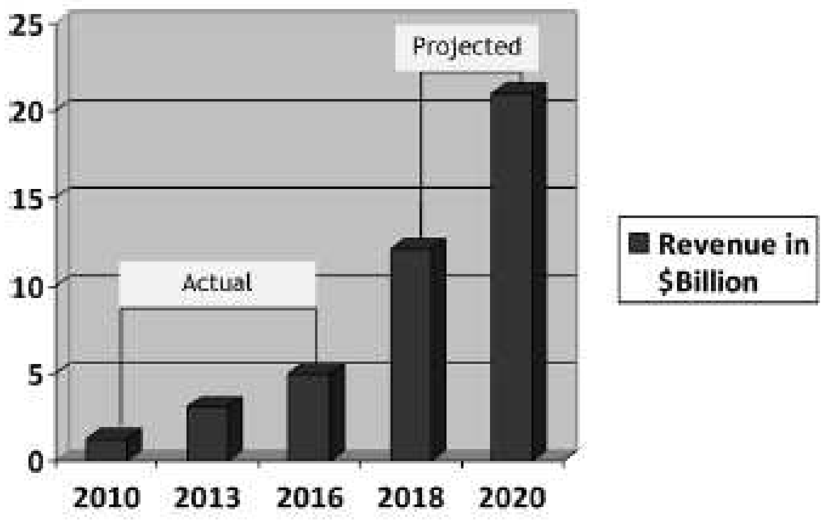


Figure 19: Worldwide AM revenue (Attaran, 2017)

4.3.4 Future of Additive Manufacturing

While additive manufacturing printing was long only used by big companies and researchers, recent price drops made them available for a wide audience. 3D Printers for plastics can be bought at Amazon from around 250€ ("Search on Amazon.de for: 3D printer," 2018). This makes them readily available for home use. Rayna and Striukova (2016) are even discussing the possibility of 3D printer following the examples of PCs by becoming an essential in most homes. This would be a major disruption of the current business models of most companies since people would be able to produce many things simply on their own instead of buying them. This scenario of home manufacturing keeps getting pushed into the future for many years now (Rogers et al., 2016). Home manufacturing is more relevant in B2C than in B2B and therefore will not be discussed in this thesis.

With the potential to turn the whole production industry on its head additive manufacturing give companies a lot of new opportunities. It allows for new innovative products, productions methods and even new ways of distribution. It will give existing companies new possibilities and allow new ones to enter markets.

4.4 Business Model Framework for Additive Manufacturing

In this chapter the existing frameworks to describe business models will be evaluated. The best one suited to the special needs for describing the business model of additive manufactures in the B2B market will then be chosen to become the foundation for the described framework.

4.4.1 The Business Model Canvas

The Business Model Canvas (BMC) is probably the best-known framework to describe business models. This model is used e.g. by IBM and Ericsson in order to describe their business model (Barquet et al., 2011). The BMC describes a business model with nine so called "building blocks". These blocks are:

1. Customer Segments
   A company can provide services or goods to one or many different customer segments.
2. Value Proposition
   Describing the utility for which customers are paying.
3. Channels
   How the value proposition is delivered to the customer.
4. Customer Relationship
   What kind of relationship will the company have with different customer segments.
5. Revenue Streams
   Describing how the product or service is monetized.
6. Key Resources
   What assets are essential for the business model.
7. Key Activities
   What are the necessary activities to make the business model work.
8. Key Partnerships
   A map of the strategic partners and suppliers.
9. Cost Structure
   The cost to operate the business model.

The nine building blocks together build the Business Model Canvas. According to the inventors it works best when printed out on a big scale and is then filled out in a team effort. The process to fill it out is intended to be a creative session with post-its, sketching and an open discussion. (Osterwalder, 2004)

BMC is integrating a lot of techniques from other modern methods like design thinking, scrum, storytelling and more. As an example, BMC uses an empathy map to create a picture of a customer, similar to what is used to create personas in design thinking. Other examples are the fast prototyping used when creating new business models like in scrum or presenting your business model as story. These are all techniques that are used in a lot of businesses and are todays state of the art. This makes the Business Canvas Model appealing, especially to companies that already use these methods because they know most of the tools already. Besides the usability when creating the Business Model Canvas, tools like storytelling are helping to create a business model in such way that in can be communicated intuitively. Since the business model is a layer between strategy and operational it needs to give guidelines that can be executed by the operational side. For this execution a thorough understanding is important and this is where storytelling helps.

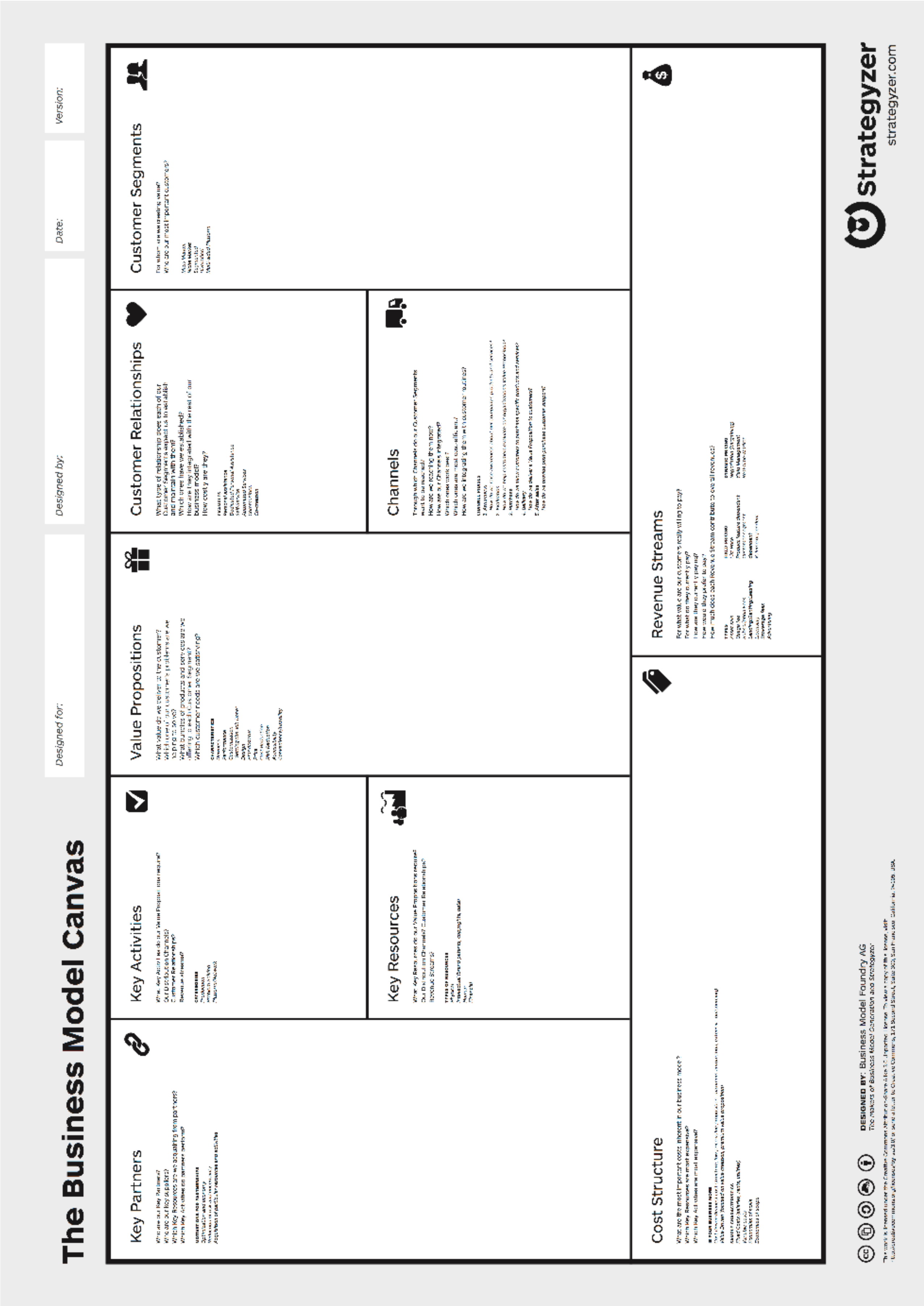


Figure 20: Business Model Canvas (Business Model Alchemist, 2010)

4.4.2 St. Galler Business Model Navigator

The St. Galler Business Model Generator was created by analyzing successful business models of the last 50 years. The authors and developers Gassman, Frankenberger, and Csik (2017) believe that in the future competition will not be between different services and products but between business models. They think that finding new innovative business models will be essential for companies to be successful in the future. Success stories of companies like Amazon, Netflix, Pixar and more are seemingly supporting the claim that innovative business models do make successful businesses. This is why they invented the St. Galler Business Model Navigator. It tries to give a structured method to innovate existing business models. This should help more companies to come up with creative new business models. The model underlying the St. Galler Business Model Navigator has four dimensions which are depicted in a "magical triangle" as seen in Figure 21:

1. **Customer – who is the target market?** Customers must be the center of every successful business model. Understanding what customers want and need is vital to every business. Only if customer needs are understood the right customer segments can be addressed.
2. **Value Proposition – what are we offering the customer?** The value proposition is describing everything that is of value to the customer and includes actual products as well as services. The value proposition is what should satisfy the needs of the targeted customers.
3. **Value Chain – how is the value proposition created?** In order to deliver the value proposition to the targeted customers certain activities and task are necessary. The coordination of tasks along the value chain with the required skills and resources in a business is the core of this dimension.
4. **Value Creation – how value is created?** This dimension not only ask how value is created but also how it is captured. Creating a valuable product is not enough, a company must also be able to monetize from it and therefore capture the value. Capturing value is one of the most complicated parts of business innovation as examples like Twitter and Snapchat are illustrating. Both have a wide user base but both are struggling to convert this into revenue. The dimension includes cost structure and revenue generation as parts of it. (Gassmann et al., 2017)

Figure 21: "Magic triangle" four dimension of business models (The Learning Wave after Gassmann et al 2015)

In short, the St. Galler model asks the questions: who are the customers, what is sold, how is it sold, and what is the value? The first two question are external dimensions and the latter two are internal dimensions. The triangle is called “magical” because the optimization of one corner requires automatically to think about the two other ones. For the authors a business innovation is at least changing two of the four dimensions otherwise they consider it a process or product innovation. A successful business model innovation is not only creating value but also protects the created value from the competition. (Gassmann et al., 2017)

The generation of new business models with the St. Galler Business Model Navigator (Figure 22) is based on the assumption that creative imitation and recombination can lead to successful new business models. Their research showed that 90 percent of successful business models are not new but actually adaptations of existing business models. The adaptation happens in four phases: Initiation, Ideation, Integration, and Realization. Relying on existing business models allows to learn from mistakes of others and prevent one from repeating them. The St. Galler Business Model Navigator gives 55 patterns that make up most business models. With these patterns businesses have orientation where they are in the market. From that position they can start to creatively imitate and recombine into new business models.

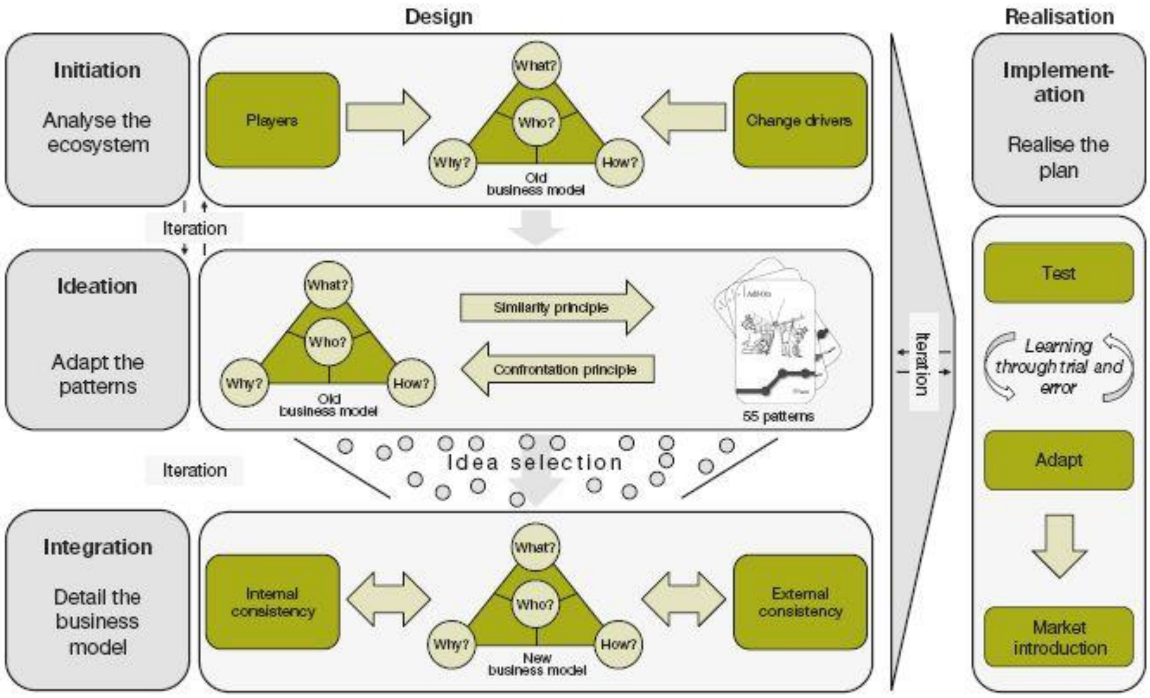


Figure 22: St. Galler Business Model Navigator (Gassmann et al., 2014)

4.4.3 Business Model Component Framework

The Business Model Component Framework is the result of an extensive analysis of different literature and frameworks describing business models. By analyzing 34 works on the topic they came up with 20 components which are clustered into 5 categories. The groups are Value Creation Model, Value Offering Model, Value Capturing Model, Cooperation Model, and Financial Model.

Value Offering Model

Describes what business value the business model is proposing the customers and partners with the offered products and services. Further it describes the competitive model and how it offers an advantage compared to other competitors.

Value Capturing Model

Describes which customers and market segments are in scope and how they are addressed. Customer relationship is another aspect that plays into this group.

Value Creation Model

Here the actual value creation is described by capturing the necessary resources, abilities, activities, processes, and the organizational structure.

Cooperation Model

Describes the partner network necessary to deliver the value and the position of the own business in this network. Coordination in the partner network and its maturity are also described here.

Financial Model

Here the financial fundamentals are described like how the model is funded, how revenues are generated, what is the price structure for offered products and services, what is the cost structure, how is profit generated, how it is distributed.

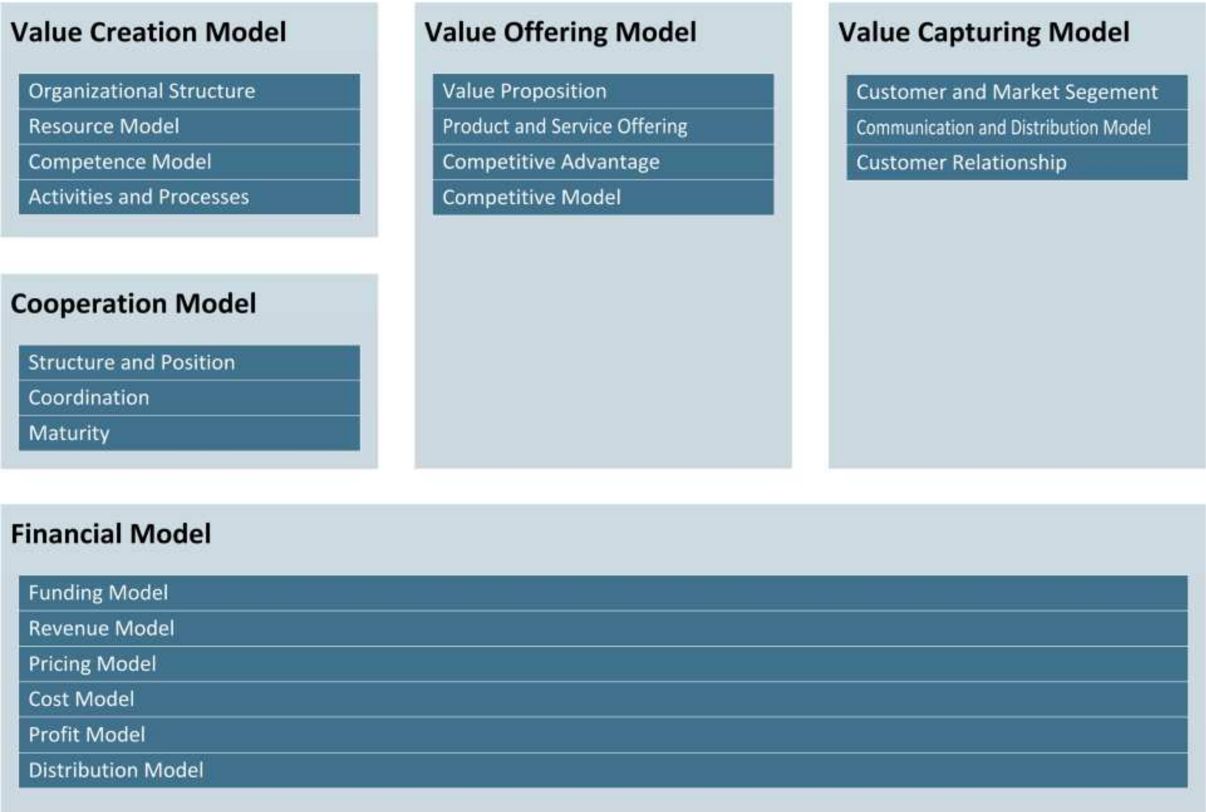


Figure 23: Business Model Component Framework (Krumreich et al., 2012)

The Business Model Component Framework can be seen as a scientific way of harmonizing and consolidating the different models for business model description. Due to the lack of scientific papers and publications on AM business models it lacks general applicability for the purpose of this paper, but what was used is the idea of aggregation although in a slightly different way than done here.

4.4.4 Comparing the Business Models Frameworks

All three of the described Frameworks have their up- and downsides. While one is good in giving guidance the other is better in being adaptable. In order to find the most suitable framework to describe additive manufacturing business models those differences had to be illustrated. For this reason, a comparison of the described business models was done. The comparison is partly based on the literature and on the experience of the author trying to apply the frameworks on different use cases. Figure 24 illustrates which of the frameworks has strengths in what areas.

Framwork	Business Model design	Guidance by examples	Readability	Adaptability	Orientation on Aspects
Business Model Canvas	◕	◔	◕	●	◑
St. Galler Business Model Navigator	◑	●	◑	◕	◔
Business Model Component Framework	○	◔	◔	◔	●

Figure 24: Strengths and Weaknesses of different Business Models, own illustration

In the following briefly the reasoning behind the comparison is explained:

- **Business Model Design** is clearly one of the strong suits of the BMC. It can be combined with different creativity tools and there are software tools to help creating business models canvases. The St. Galler Business Model Generator is helping the design of business models by offering patterns which can be used as orientation. This is not as intuitive as the tools offered by the BMC but still very helpful. The Business Model Framework itself is not offering any advice on how to generate a business model and therefore is scored with the lowest score.
- **Guidance by examples:** Here the St. Galler Business Model Navigator scores the highest. The relatively simple stories provided to the different business models allow practitioners to compare their business to those in the example. The other two are scoring rather low since they only give finished business models as example but very low context with them.
- **Readability** means how quickly can you understand the business model created with the framework. Here the Business Models Canvas again is best

in class. The nine segments can be all seen at a glance and give the reader a clear and concise overview of the business model of the company. The St. Galler Business Model gives more context to the business model but it has no visual representation of the business model which reduces makes it less intuitive. The Business Model Component Framework is only giving the general topics a company should consider when creating a business model. These aspects can all be seen on a glance but are not giving any information about the specific business model.

- **Adaptability** means that an existing business model can be changed to in some aspect to represent for example changed environments. Here the Business Model Canvas shines because it is easy to add or remove aspects of every segment of the business model. The St. Galler Business Model Generator is giving tools to adapt the business models but since the business model is written in plain text significant rework is necessary when changing a business model.
- **Orientation of aspects** is where the Business Model Component Framework really shines. It shows every aspect that a business should look into to find their business model on one page. This gives good orientation for the creators. The Business Model Canvas is showing a lot of the same aspects but not all of them and this is why it is not scoring as high. The St. Galler Business model is not giving a lot of orientation other than the three aspects on which it is based. These aspects are rather high level and a lot of reading has to be done to find the underlying concepts. Therefore, it scores the lowest.

The flexibility given by additive manufacturing companies allows companies to produce new parts that where not in the portfolio of the company before since no new machines are needed. This allows to enter related markets or even new ones. This reduction of needed machines during the production process also means that companies can increase their scope. They can move their production scope up- as well as downstream and thereby create more value themselves. For example, an AM injection tool producer could start producing the part itself instead of the tool. This would mean the company is moving downstream and therefore closer to the end customer. In reverse a company that produces parts with AM could start producing tools for other products with AM. Therefore, they would integrate the process of producing tools and with that move upstream the value chain. In conclusion it can be said that additive manufacturing makes business models more agile. It allows companies not only to move into new or related markets it also allows to move a company with relative ease down- or upstream of the value chain.

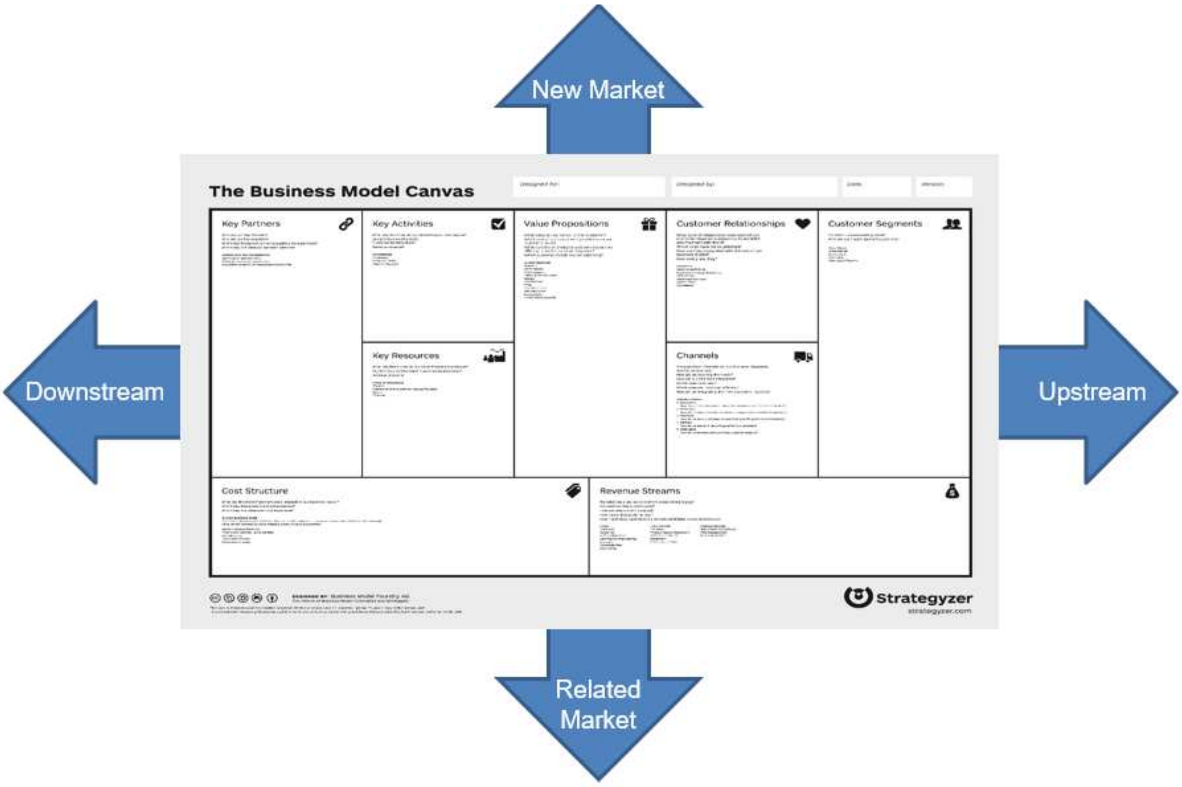


Figure 25: AM makes business models more agile

5 AM Business Model Generator

This chapter describes the developed framework to evaluate the business model of additive manufacturing companies. The framework is called AM Business Model Generator. The framework is synthesized out of the theory in the earlier chapter and use cases of additive manufacturing described in literature.

5.1 Basic Framework

After researching different frameworks for the describing business models, it became apparent that the Business Model Canvas is the most advanced and most known framework for visualization. Since usability and acceptance by practitioners are key aspects for choosing the business model the choice was made for the Business Model Canvas as Basis for this thesis. Despite the good foundations of the Business Model Canvas it has some short-comings. Especially in the regards of creating new innovative business model, as it would be necessary for additive manufacturing companies in the B2B market it has limitations. Consequently, the idea of creative imitation and recombination from the St. Galler Business Model Navigator is used to create Business Model Canvases for the businesses active in different areas of the value chain. To do that the most relevant aspects of every building block from the Business Model Canvas relevant to additive manufacturing needed to be identified. With the relevant aspects known they then can be combined into canvases, which then help organizations to find their business models by giving orientation. The combination of Business Model Canvas and St. Galler Business Model Navigator allows to pick the best from both sides. The Canvas model has clear advantages for describing the business model because it is more detailed and on a more applicable level. On the other hand, the St. Galler model of describing business models is more general. Since applicability is one of the key principles for the framework the Business Model Canvas method was chosen for describing the business model.

To find the key aspects of every building block a key inspiration came from the Business Model Component Framework. As mentioned before the literature of scientific papers does not allow to create the full set of aspects necessary, since the aspects are rarely or never expressed explicit. Non-the less the scientific papers about AM can be used as a starting point to find the key aspects.

5.2 Key Aspects

To get all the relevant aspects, it was important so find as many possibilities for every area. In order to achieve this goal a twostep process was in place. The first step was a methodical literature research through papers and articles about additive manufacturing. While going through these texts all described business model possibilities were collected and ordered by the nine segments of the Business Model Canvas. After this initial collection of possibilities described in scientific literature the goal was to create a method to find more options and at the same time try to connect the existing ones. This was done using the collected possibilities and applying them to the Value Proposition Canvas (Figure 26). The Value Proposition Canvas is another tool created by Osterwalder - the inventor of the Business Model Canvas. It is supposed to align value propositions of products and services with customer profiles (Osterwalder et al., 2015). Starting from the value proposition the fitting customer segments were collected. This was done by matching the actual offered products and services to the customer jobs. Customer jobs are everything a customer is trying to accomplish when buying a product or service. This can be split into two areas, pains and gains. Pains are circumstances in the market that put pressure on companies. Examples for pains would be restrictions on contracts by law, excessive costs for development, high degree of innovation and many more. Gains are what is actually creating a higher value for the customer and what customers are willing to pay for, like new product features, consulting, opportunity for customization etc. In short it can be said that pains are things that the product needs to fix in order to be even considered worth buying. Gains on the other hand excite customer and lead to premium prices paid by them. This method is can be used to create many different value propositions and find the fitting customer segments for it.

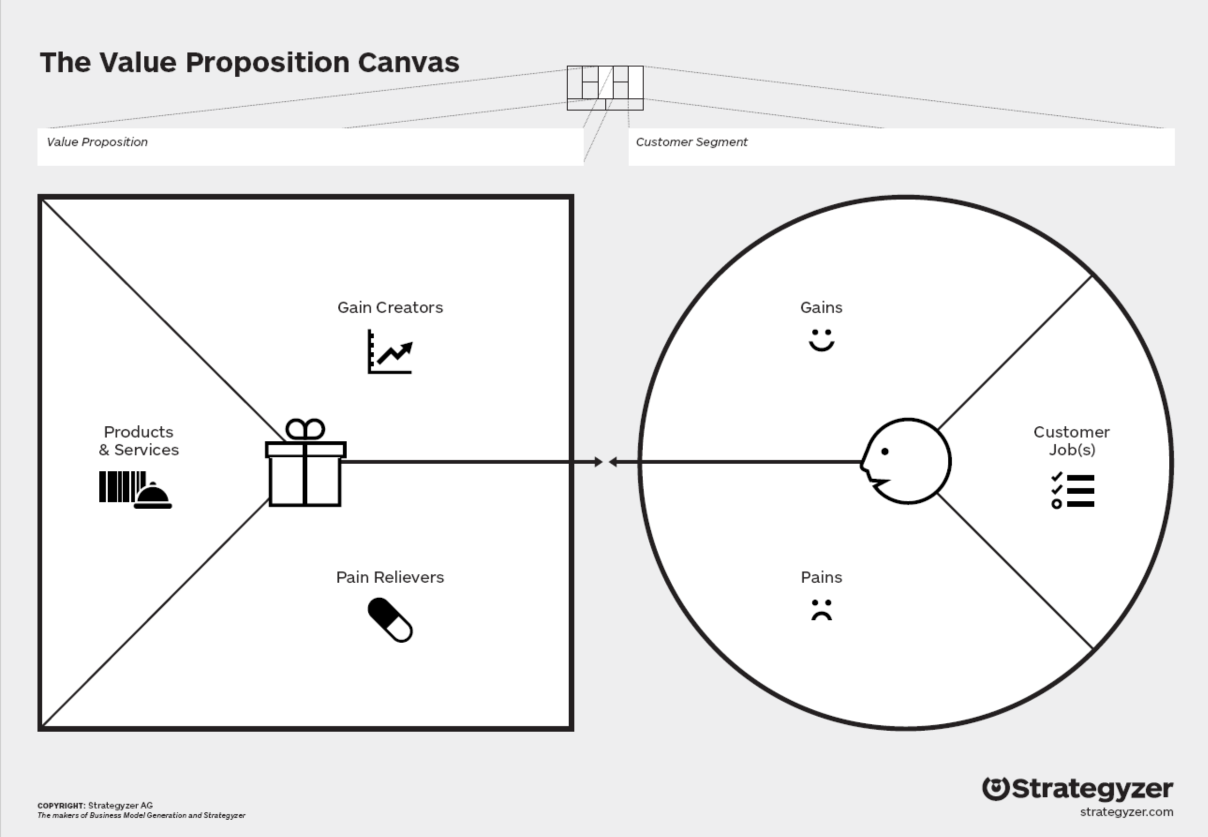


Figure 26: The Value Proposition Canvas ("Strategyzer.com," 2018)

After collecting the key aspects, the next step was creating generic Business Models starting from the value proposition. The value proposition was used as the starting point because it is often viewed as the most important aspect and in this context also the most unique one. With the value proposition as a starting point more than 20 different Business Model Canvases were created. During the creation of the different Canvases it became apparent that for some value propositions the other dimensions were very similar. This similarity can be attributed to the value proposition being in the same phase of the value chain of additive manufacturing. At the time of the creation of the AM Business Model Generator there was no clear definition of the value chain of additive manufacturing companies. Therefore one had to be created.

5.3 Value Chain of additive manufacturing:

To find a suitable value chain for additive manufacturing it makes sense to look at existing value chains and at the specifics of AM. Figure 27 shows how Siemens sees the value chain of automotive manufacturing. The goal of this chapter is to find something comparable for additive manufacturing.

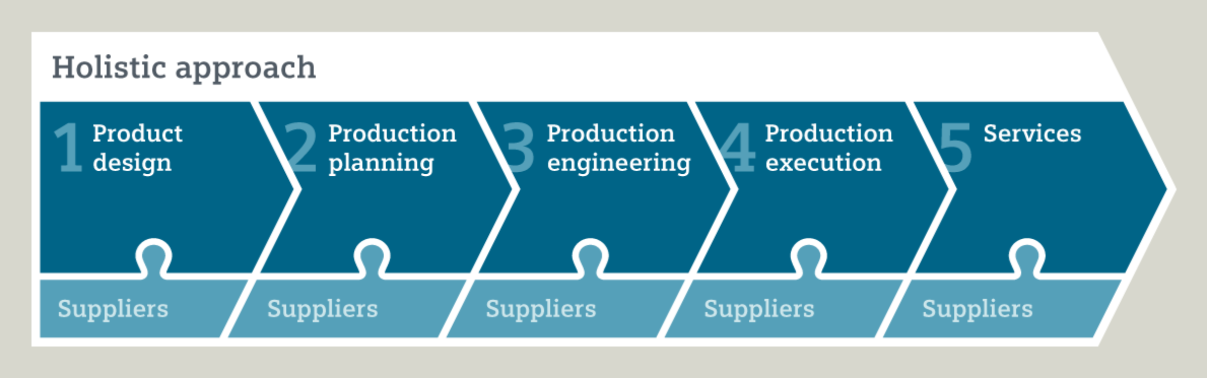


Figure 27: Siemens Value Chain for automotive manufacturing (Siemens.com, 2018)

In the theoretical chapter (4.3.2 27Process Steps of Additive Manufacturing) eight steps of additive manufacturing were described: CAD design, conversion to STL, transfer to machine, machine setup, build, removal, postprocessing, and application. This is to granular for describing the value chain in relation to AM businesses. For the purpose of this thesis it was therefore necessary to define a suiting value chain. The criteria for identifying a single step of the value chain is defined as what part a business could offer independently. To meet these criteria, it was necessary to merge some of the steps of the basic additive manufacturing process steps. The reasoning behind joining the steps is explained in the following paragraph.

It seems unrealistic that a business would set up the machine but then not build the product, because the setup would need to be specific for a part. Machine setup and build are combined in the step manufacturing. The steps transfer to machine of the STL and removal of the part from machine is merged into the phase of built. This leads to a value chain of additive manufacturing with five phases: part design, pre-processing, manufacturing, post-processing, and part assembly (Figure 28). A business can offer all of those phases or just certain combinations of it. There are some combinations that seem more likely than others and we will look into this later but for now let’s look at the different parts more detailed. The order is the chronological order every AM-part has to go through.

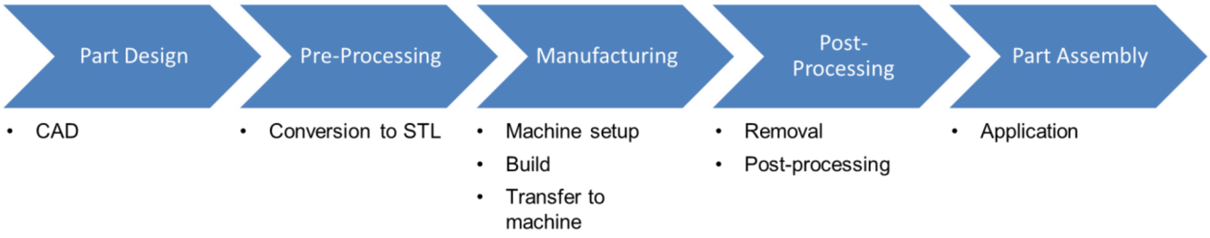


Figure 28: Steps of AM compared to Value Chain of additive manufacturing

Part Design: CAD is the basis on which additive manufacturing was created and part design for AM always includes some form of CAD (Gibson et al., 2010). While additive manufacturing is used in rapid prototyping by now for more than 30 years it had very little effect on the designing process. Now that additive manufacturing is pushing to become a normal production alternative it also starts to change how parts are designed. Designing parts for additive manufacturing is significantly different than designing traditional parts. While it allows for great freedom in geometry it also has some restraints. For 3D printing with a nozzle that is spraying the material, it is better to have curves when designing parts for AM, since sharp corners lead to high accelerations of the nozzle which can lead decreased accuracy while printing. This means sharp corners should be avoided. Another aspect that needs to be considered is heat dissipation if using a layer based additive manufacturing. If heat cannot dissipate quickly enough the material stays liquid for too long which leads to distortions and inaccuracies. With the possibility to create very thin and complex structures the stability during the production needs to be considered. Often the raw material itself is used to stabilize the structure. Then it needs to be considered how to extract the material in order not to end up with filled cavities. This is something inherently unique to AM and therefore a challenge for designers not experienced with it. (Vayre et al., 2012) This is only a selection of novelties of AM part design. It is only logical that traditional part designers are struggling with the new possibilities and restrictions. This internal lack of knowledge can lead businesses to outsource the product design for additive manufacturing products.

With new technologies available it is possible to create CAD files directly from the real object. This technology is called 3D scanning. While 3D scanning by itself has nothing to do with AM it is often used in combination. It allows to create variations or copies from existing objects with a lot less effort than when starting from scratch. This means that not only newly created parts are falling in this part of the value chain. Parts which were created for traditional manufacturing but are transferred to AM need to be checked for suitability. Checking if a part is suitable to be created with AM methods also falls into this part of the value chain. This is especially relevant for parts that used to be created with traditional production methods and are switched to AM now. An example for this could be spare parts that no longer get produced by the original manufacturer and now are copied with AM in order to keep the original machine running. Almost all additive manufacturing parts are anisotropic, which means they have different properties in different directions (Gibson et al., 2010). Most parts created with classical production methods have the same properties in all directions. This means that there are some changes or at least checks necessary even if someone is just copying an existing product. These checks and if needed changes would be done in the designing phase too.

Pre-Processing: The first step in pre-processing is converting the CAD file of the designed part into the STL file format which is the standard input for most AM machines. During the conversion all construction data, modeling history and other information is dropped, and the surface of the part is approximated with triangles. Without going into too much details it can be said that the size and the orientation of the mentioned triangles is important for the quality of the finished products. Mistakes can lead to wrong surfaces or production mistakes. Wrong orientation of the triangles for example could lead to material in places where no material should be or vice versa. The orientation of triangles is only one aspect that needs to be considered when transforming a CAD file in a STL file (Wong and Hernandez, 2012). Because it is an approximation of the original there are complicated steps that can lead to errors. While the software is doing most of the heavy lifting during the transformation there is still some manual input and know-how necessary. Especially for sanity checks after the transformation experts are required. The last step in pre-processing is called finalizing. This is when the level of detail is selected, and the STL-file is created. Finding the right amount of details needed is important. STL builds with a high degree of details require high processing power which increases costs for all the computers involved in the processes from processing PCs to the computers controlling the 3D printer for example. Some AM machines even have limitations on how big files can be. On the other hand a part can never become more detailed than the STL-file (Stratasysdirect.com, 2018). Therefore, the transformation needs to be done by a professional with the correct software tools and the knowledge to find the right balance between required detail and file size.

Manufacturing: After the successful conversion to a STL file it will be transferred to the machine on which it will be built. On the machine certain adaptions can be necessary. For example, the position of the produced part in the machine could be selected or how many parts should be produced simultaneously. The parts created can be copies of each other or completely different ones. During this stage of the process the STL file is also adapted in regards of shrinkage or to take coating into account. (Gibson et al., 2010)

After the transfer to the machine it is time setup the machine in such a way that the finished product is meeting the quality standards set for it. This requires for example to specify the layer resolution. A lower layer resolution can lead to faster production time but on the other hand to unacceptable surface quality. In this stage expert knowledge of the specific machine in use is required. After setting up the machine in the right way the part can finally be built. Often it is necessary to make some corrections during the setup phase. So, in the beginning the built phase is a semi-automatic process which gradually becomes a fully automated one (Gibson et al., 2010)

Almost all AM technologies work on a layer-based principle. These layers are produced during this phase. Depending on machine and part to be built the removal of excess material is happening during the built or separately in a process after the actual built of the part.

After the manufacturing of the product is done it needs to be removed from the machine. Since some production methods result in products welded to the base plate the removal can be a difficult task that requires a lot of time and manual work. Improvements during the removal phase could lead to big gains in productivity (Wohlers, 2017). Additive manufacturing in general has a lot of potential for improvements in many aspects of production. From prototyping to distributed manufacturing, AM made significant advancements and creates new value. Nonetheless there are still improvements to be made. AM has to become faster, more reliable and easier to use (Attaran, 2017). These aspects are all mainly related to the actual production of AM parts and therefore companies are trying to improve this technology the most. Improvements in any of these areas would give businesses a clear advantage over their competitors.

Post-Processing: Ideally the parts built with AM are directly usable for application, unfortunately this is very rarely the case. After the part is built and removed from the machine often some features remain that are not intended for the finished products. Features like supporting bars are often necessary but need to be removed before the parts can be further processed. Due to the fact that AM parts are often very complex post-processing is often a manual or semi-automatic task.

Most current AM production methods are not resulting in the required surface and some post-processing in the form of sandpapering, polishing or coating is necessary. Furthermore in order to meet the needed characteristics in regards of hardness and strength parts need to be heat treated during the process (Metal-AM.com, 2018). The degree of effort necessary depends on the requirements of the part, the used materials, and machines involved.
Testing the part would also belong into this phase of the value chain. While this can include traditional tests for surface quality, functionality etc. the most relevant testing technique for additive manufacturing is non-destructive testing (NDT). The possibility to create complex parts with cavities allows for lighter products but it also makes it harder to detect production errors. Due to the complexity of AM, with up to 50 process parameters distributed over different agents, reliable quality control only by process control alone is hard to achieve. The fact that AM is often used to create parts that are used in highly critical fields like automotive or aerospace where failure can have devastating consequences underlines the importance of critical testing (Hole, 2016). This makes testing capabilities with non-destructive technologies like computer tomography or ultrasound a very valuable asset to have.

Application: The last step in the value chain of AM would be the application of the parts. Application can be assembling the produced part with other parts into a module or a finished product. The other parts do not necessarily have to be additive manufacturing parts themselves. A big field of application for AM besides producing parts is the creation of manufacturing inputs. As explained in the theoretical part (see chapter: 21) manufacturing parts are a direct input in creating a product. Injection molding tools would be a good example for such manufacturing parts produced by AM. Technologies like powder-bed systems, sometimes also called by tradenames like Selective Laser Melting or Direct Metal Laser Sintering, can be used to produce injection molding tools with better characteristics and faster than traditional tools.

Assembly for AM products can look like any other assembly, but due to specialties of AM it can also require some special handling. The anisotropic characteristics of additive manufacturing parts distinguish them from traditional parts. Because of this the orientation when using AM parts is critical. While they should be designed in a way to prevent mishandling assemblers, user of AM parts still need to be trained to handle them correctly and to keep in mind that they behave differently than classical parts.

Depending on where a business is operating in this value chain it will have a different Business Model. Where organizations fit into this value chain is what look at next.

5.4 Value chain business model options

While it would be possible for businesses to offer every step of the value chain separately or in any combination, it is likely that some combinations occur more often than others. In the following the focus is on the combinations of steps from the value chain that are seen as most probable. For the businesses operating in most common areas of the value chain Business Model Canvases will be provided. This will give organizations better orientation and a starting point to find their exact business model. But before that the different possibilities have to be defined and described. Through comparing AM businesses with traditional B2B businesses and taking into account the specifics of additive manufacturing, six different combinations were identified. These six groups of businesses are named the following:

- AM Designer
- AM Designer and Digital Processer
- AM Manufacturer
- AM Contract Manufacturer
- AM Supplier
- AM Original Equipment Manufacturer (OEM).

Each of these groups is offering a specific part of the value chain and therefore needs a specific business model to be successful. In the following the six groups and their business models will be explained in more detail. The business models proposed here are based on the literature review and are far from the only ones possible for a company acting in the described areas. They describe some of the business models possible among a certain set of value propositions. For every area of the value chain there are possibly more value proposition available but in this thesis the focus is on the most promising ones. Starting with the business model that offers the shortest part of the value chain (AM Designer) and ending with the one that offers the full value chain of additive manufacturing (AM OEM), all the relevant Business Model Canvas will be explained.

AM Designer:

Figure 29: AM designer value chain

Basically, this is a product designing business that has deep knowledge of additive manufacturing. It is the simplest version because it only uses the first stage, (Figure 29), of the value chain. A typical scenario for an AM Designer would be if the production is done by an AM Manufacturer which wants to a unique design to be recognized by customers. Therefore, the AM Manufacturer hires an AM designer with creative ideas to get a product that customer would find appealing. The product itself will only be created digital, most likely it would be a CAD file. The digital file then will be handed over for further processing to the AM Manufacturer. AM Designer need a strong focus on their employees since their strongest asset probably will the their knowledge.

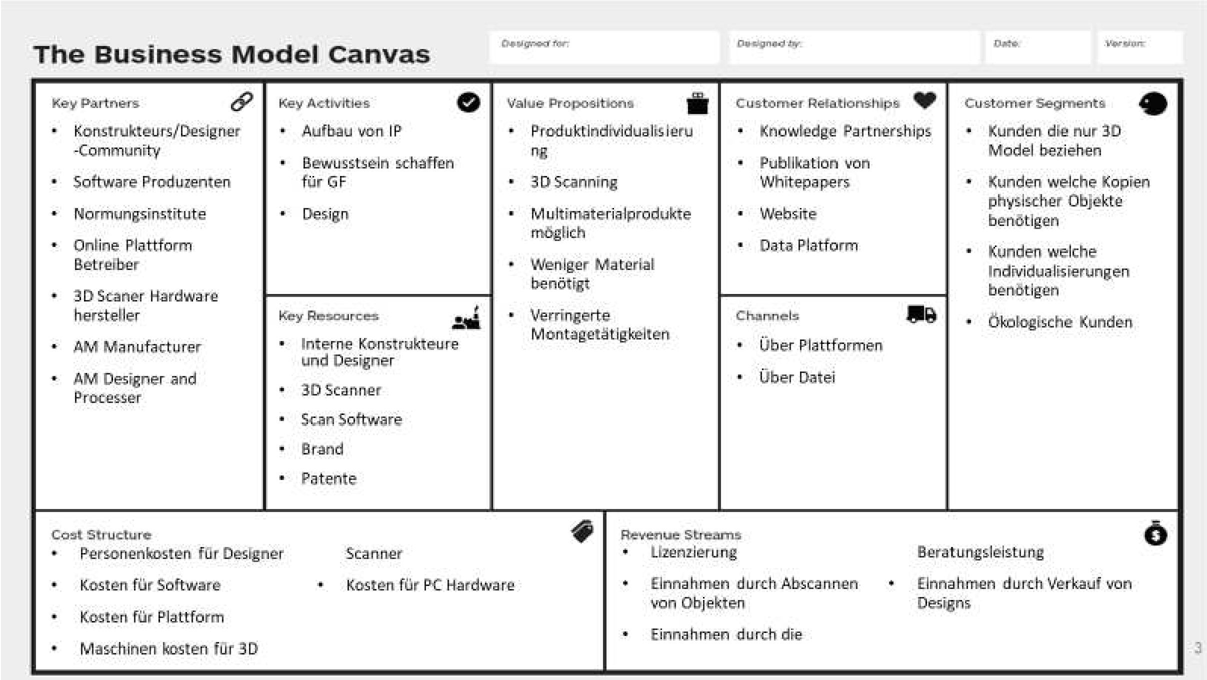


Figure 30: Aspects of AM Designer business model

If a business is identified to fit into the AM Designer part of the value chain the question is how a concrete business model for such an AM Designer would look like. First there are different aspects for all nine building blocks of the Business Model Canvas as seen in Figure 30. As explained earlier these aspects are for orientation and do not have to be applicable in total. More likely than not some aspects have to be taken off and some have to be added.

This is what have been done with the following Business Model Canvas. It describes an AM Designer that specializes in complex geometries. The main Value Proposition is therefore **Creation of complex designs** and **High degree of form freedom**. This has a great fit to their customer segment **Customers that reached the limit of traditional designs** and **customers that need complex geometries**. A possible example for such a customer could be an aircraft manufacturer that reached the limits of weight reduction in turbines with traditional production methods. The creation of such complex designs requires skilled **Designers** and **Engineers** as key resources. The Key Activities of those would be first **Creative Design** of new product. In order to achieve this the company must **Find new solution possibilities**. The new-found solutions can then be used to **Build up intellectual property** which can generate revenue. Key Partners for this sort of AM Designer are: **Engineer/Designer Community, AM Manufacturers, and Research Facilities** –

for connecting with other AM professionals and getting new ideas, **Software manufacturer** – to get the right tools for creating designs, **Education facilities** – for hiring new talented designers and engineers, and last but not least **Legislator** – in order to stay atop of legislation of what is allowed and what not. Customer Relationship is done first through **Knowledge Partnerships**, this means the designers work closely with the customers to understand their problems and build ties. **Publication of whitepapers** about hot topics show thought leadership in these areas and last the website is first contact point for most interested customers. Since the company is only offering digital products the channels are either a **Platform** through which files are exchanged or a **File** is getting handed over via CD or any other medium possible. Designers like this mostly have to consider personal costs as their main expenses. Besides **Costs for Designers and Engineers** only the **Costs for Software** are affecting the cost structure. Revenue Streams would be the S**elling of Designs**, this would most probably be the most important one. Further revenue can be generated through **Counseling fees** and **Licensing** of intellectual property.

Figure 31 is how the just described business model would look in a business canvas.

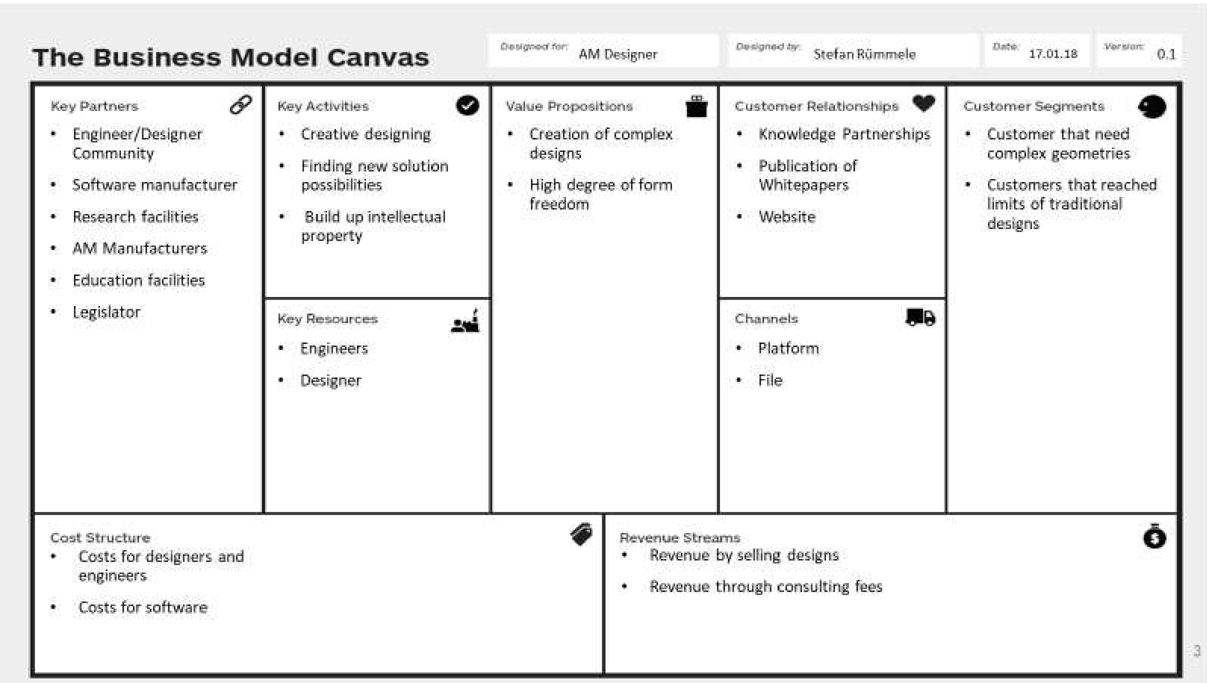


Figure 31: Possible business model for AM Designer

AM Designer and Digital Processer

This is a designer that is also providing the Pre-Processing of the part in contrast to the pure designer who is only providing the part as a computer model. Normally this would occur in combination with an AM contract manufacturer, who is just getting the STL file. This could be similar to what thingiverse.com is doing in the private consumer market. Thingiverse.com is an open platform where every designer can share his designs in the form of STL-files. While on this platform most designs are free and aimed at consumers, something similar could definitely be done for Businesses. The AM Designer and Digital Processer is normally not doing the transfer to the actual machine, but their customers do.

Figure 32: AM Designer and Digital Processer value chain

AM Manufacturer: An AM Manufacturer as seen in Figure 33 would be a producer of parts which has established designs. Maja Möbel would be an example for such a manufacturer in a different industry. The core competence of Maja Möbel is realizing the ideas of Ikea production wise and not the creation of designs (Dierig, 2016). An AM Manufacturers focus lies on the three steps pre-processing, manufacturing and post-processing. With this focus they often produce parts in high numbers that are inputs for other products. Their strength lies in the cost-effective production of these parts by having stable processes. They perfect the STL-File from the input design to fit to their production method. Cost effectivity for them could get achieved by automating the handling of parts between Manufacturing and Post-Processing.

Figure 33: AM Manufacturer value chain

AM Contract Manufacturer:

AM Contract Manufacturer as depicted in Figure 34 are pure producer of parts. They have a flexible machine setup and therefore are able to fulfill a wide array of production jobs. With their concentration on the steps manufacturing and post processing they are able to produce parts at a competitive price. Contract manufacturer are widely used in many industries. In the textile industry companies like the Hameem Group are producing cloths for many different customers like H&M or Zara. They are often very flexible in their production methods and can therefore take on a wide array of assignments. With their flexibility they are perfectly suited for load balancing. This means they can take over some of the production volume from a client during seasonal highs. Load balancing is typically done with software but not that common for manufacturing companies. This makes the AM Contract Manufacturer special because this type of business is really opening up new opportunities. While some small companies are

Figure 34: AM Contract Manufacturer value chain

AM Supplier:

The AM Supplier in Figure 36 is offering the whole additive manufacturing value chain except the assembly. On a basic level AM Supplier are not much different than traditional manufacturing suppliers, like for example in the automotive industry. Supplier produce finished parts for products but do not assemble them for use. Continental produces tires and then sells them to car manufactures for use. Their strong suit is that they control the whole process of the production of the part. Often supplier have a strong focus on certain niches in which they specialize. The combination of process control and specialization allows them to build up a lot of knowledge about their product and the manufacturing process

Figure 35: AM supplier value chain

AM Original Equipment Manufacturer:

AM Original Equipment Manufacturer (OEM) are active in the full spectrum of the AM value chain. They are doing everything related to additive manufacturing end-to-end. OEMs are companies that produce complete products but are not selling them under their own name. Their focus is on B2B therefore the end product is mainly sold to retailers, wholesaler, or dealers. This means they are usually not in direct contact with end customers. A good example for an OEM in other industries is the electronics manufacturing company Foxconn. Foxconn is producing for example complete motherboards which then are sold by another brand (e.g. Intel) under their name to the end customer (theinquirer.net, 2009).

Figure 36: AM OEM value chain

5.5 AM Business Model Generator Framework

In Figure 37 we see how the process of the framework works. It starts with a short explanation of how the framework is actually working. Then the framework itself has two different customer segments, businesses that are currently active in additive manufacturing but have no formalized business model and businesses that are planning to get involved in AM. It helps both groups by giving them orientation where they are in the value chain and which of the six business models is most applicable to them.

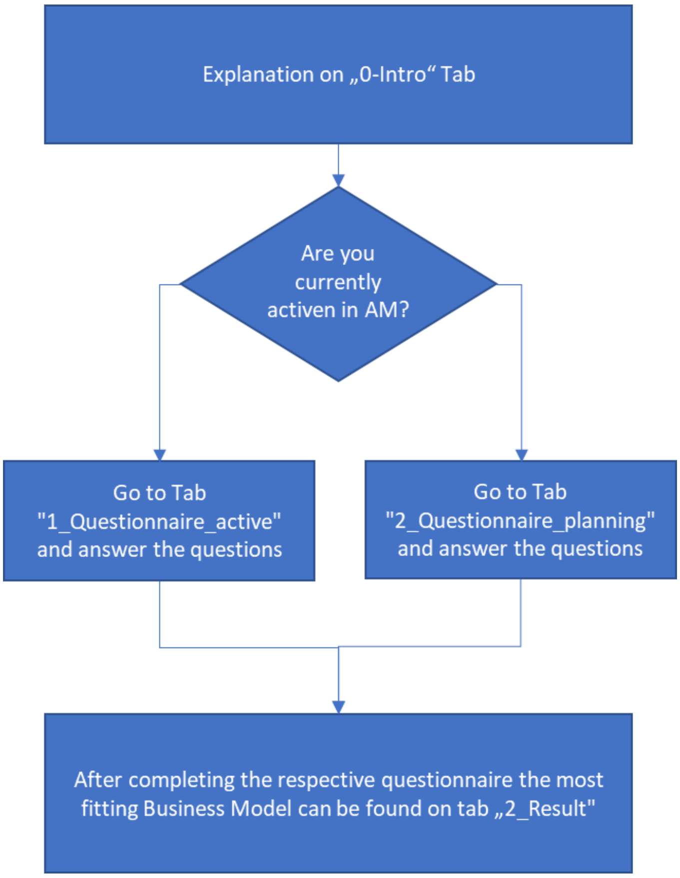


Figure 37: Flow chart of the framework

In order to do that there is a distinctive questionnaire for both groups. The questionnaire for businesses already working in AM is asking about what the business is currently doing and aspiring companies what they see as their fields of interest. The questionnaire works with a Likert-scale with five scale points per question. Every question asks about how important certain tasks along the value chain are to the business. For tasks seen as very important the maximum of five points is rewarded. Then with declining importance the points are declining to the minimum of one point for none important tasks. The average of points rewarded for tasks in a certain area of the value chain is indicating the importance of this area to the business.

Questions for practitioners

Question
How important is creativity for you when hiring new designers?
How important is your company to create 3D scans?
How important are reviews of designs for AM suitability for your company?
How is high the potential for existing designs for adaptation for AM?
How many of the STL-files currently in use did your company create?
How often do you check STL-files for other businesses?
How important is your company's definition of build parameters?
How important is your company to finalize STL files?
How important is it for your company to determine the machine parameters themselves?
How high is your AM manufacturing expertise ?
How often do you improve your manufacturing method in the last year?
How many process parameters are you tracking?
How high is the level of automation for the removal of parts from the AM machine
How high is the percentage of parts controlled with methods like ultrasound, CT, etc.?
How high is the percentage of heat treated AM parts?
How often must features be removed from parts?
How many different surface treatmens are you performing?
How high is the percentage of AM parts in your finished moduls?
How high is the percentage of AM parts in your finished products?
How suitable are AM made manufacturing inputs for your production

Questions for future practitioners

Question
How interested are you in creating your own designs?
How interested are you in creating 3D scans?
How interested are you in testing good designs for AM-fitness?
How interested are you in optimizing existing designs for AM?
How interested are you in creating STL files?
How interested are you in checking the existence of STL files for correctness?
How interested are you in setting the build parameters?
How much are you interested in finalizing STL files?
How much are you interested in defining the machine parameters yourself?
How interested are you in the actual production of parts?
How much are you interested in improving production methods?
How much are you interested in controlling the production process?
How much are you interested in the process of removal from the machine?
How much are you interested in controlling produced parts?
How interested are you in the heat treatment of produced parts?
How much are you interested in removing other features after making parts?
How interested are you in the surface treatment of created parts?
How interested are you in producint moduls from AM parts?
How interested are you in producing products from AM parts?
How interested are you in using AM parts as manufacturing inputs?

Figure 38: Questions for framework

When working with Likert-scale questions the acquiescence response bias must be considered. The acquiescence response bias describes the fact that people are likely to agree with questions in questionnaires even if they do not agree with the statement (Winkler et al., 1982). This means that even some parts of the value chain are not considered very important by people when asked about, it will be rated with higher importance. This would lead many businesses to land in business models which are serving more parts of the value chain than they are actually do or interested in. A good counter measure against people over valuing certain parts of the value chain is asking indirect questions. So instead of asking about the importance of something, the question would be about something measurable which can be taken as an indicator for the importance. As an example, in the questionnaire we want to know how important heat treatment is for the business. Instead of asking about his opinion the question asks: “How high is the percentage of heat-treated AM parts?”. This is a quantifiable question that allows conclusions about the importance of heat treatment. If the response is that a hundred percent of the parts are heat treated it is very important and would get a value of five. In case of fifty percent of parts being heat treated it is somewhat important and would get a value of three. In Figure 39 the relevant aspects can be seen and the corresponding questions for the AM Design part of the value chain. The full list of aspects and the respective questions for them can be found in the Appendix.

Group	Anticipated Answer	Weighting	Active Questions	Active Answer Options
Design	Company creates creative designs themselves	3	How important is creativity for you when hiring new designers?	0 - N/A;1 - Creativity is not important;2 - Creativity is not very important;3 - Creativity has some importance;4 - Creativity is important;5 - Creativity is most important
Design	Company creates 3D scans of items	2	How important is your company to create 3D scans?	0 - N/A;1 - Not Important;2 - Slightly Important;3 - Moderatly Important;4 - Important;5 - Very Important
Design	Company examines existing designs on AM fitness	1	How important are reviews of designs for AM suitability for your company?	0 - N/A;1 - Not Important;2 - Slightly Important;3 - Moderatly Important;4 - Important;5 - Very Important
Design	The company optimizes existing designs for AM capability	2	How is high the potential for existing designs for adaptation for AM?	0 - N/A;1 - No Potential;2 - Low Potential;3 - Some Potential;4 - High Potential;5 - Very High Potential

Figure 39 Relevant aspects for AM Designer

This works for AM practitioners which are already working in the field and therefore can be asked about their current state. For aspiring AM companies this is not an option since they have no empirical values to draw from. To take this into consideration another way of preventing the acquiescence response bias is necessary. Otherwise too many of the sections would be rated as important and therefore considered relevant for the business model. This would probably lead to many wrong classifications. For example, when a manufacturer is doing the removal of excessive parts after manufacturing he would give this part a high rating. Because the manufacturer does not want to rate the other process steps with one despite not applying a value of two could be given, which would put the company over the limit and place it in post-processing. That would be wrong because it is just a manufacturer that is doing one step from the post-processing. This example also visualizes the fact that a business can do single tasks from an area of the value chain without falling into specific type of the value chain. It depends on the number of tasks someone is doing from a certain area and how important that task is considered. The model chosen therefore is a different one. When calculating which business model applies to a company, six averages about every question relevant to the specific business models are calculated. From these six averages the highest is indicating which of the business models is most relevant.

Active

	AM Designer	AM Designer	AM Manufacturer	AM Contract Manufacturer	AM Supplier	AM OEM

		and Processer				
Weighted Average	1,77	3,57	4,21	3,99	3,72	3,65

Table 1: Calculation result of questionnaire

In Table 1 we can see the weighted averages calculated for all the six business models. In the example oben the red framed AM Manufacturer would be the most fitting business model, since it got the highest score. For the calculation a weighted average is used since some tasks have a higher value in certain areas than others. For example, actually designing parts are more important for being put into the design area than checking if designs are AM friendly. Because of that every question has in addition to its Likert-scale a weighting. The weighting is 3 – key task, 2 – moderately important task, 1 – support task. The answer value is the multiplication of the weighting with the value from the scale of every answer. Then the weights and the values multiplied with the answers are each summed up. In the example shown in Figure 40 we respectively get for the sums of the weight 8 and for the sum of the value multiplied by the weight we get 26. Now by dividing the multiplied values by the weights we get the weighted average. In the example this result in 26/8 which gives us a weighted average of 3,25.

										Sum
Values	5		3		4		2			
	x		x		x		x			
Weights	1	+	3	+	2	+	2	=		8
	=		=		=		=			
Value x Weight	5	+	9	+	8	+	4	=		26

Weighted Average: 26 / 8 = 3,25

Figure 40: Weighted Average explained

Depending on the score seen in Table 1 on the tab “Result” the relevant segment of the value chain is shown on top of the page. Below the classification it displays the corresponding generic business model for this part of the value chain. In the example shown this would be the AM Designer and the related business model.

Are you currently active in AM?	No
Your position in the AM value chain:	AM Designer

Key Partner	Key Activities	Value Proposition	Customer Relationship	Customer Segments
Constructors / designer community Software producers Standards bodies Online platform operator 3D Scanner hardware manufacturer AM Manufacturer Constructors / designer community AM Designer and Processer	Building IP Create awareness for AM Design	Product individualization 3D scanning Composite products possible Less material needed Reduced assembly activities	Knowledge Partnerships Publication of whitepapers Website Data Platform	Customers who only purchase 3D models Customers who need copies of physical objects Customers who need customization Ecological customers Customers who require complex parts / assemblies
	Key Resources		**Channels**	
	Internal engineers and designers 3D scanner Scan software Brand Patents		By platforms By file	

Cost Structure	Revenue Streams
Person costs for designers Cost of software Cost of platform Machines cost for 3D scanners Cost of PC hardware	Licensing Revenues by scanning objects Revenue through consulting services Revenue from sales of designs

Figure 41: Business Model option proposed by Framework

6 Framework Validation

With its flexibility additive manufacturing allows for a higher degree of mobility in the business model. With technologies like 3D printing companies can move upstream, downstream, change to related or even unrelated markets without much ramp up time (Rayna and Striukova, 2016).

Research regarding business models for Additive Manufacturing is still only starting and as the literature has shown there is not a conclusive consensus about how it should look like. What research has formed a consensus on is that Additive Manufacturing will give businesses more flexibility with their business models. Because of that a business model framework for AM businesses must enable them to try new models and allow them to think creatively.

6.1 Evaluation of used methods

The research question of this thesis results from a research project by the Institute of Management Science from the TU Wien and the Fraunhofer Austria Research GmbH. Therefore, this thesis was created in close collaboration with the Fraunhofer. The main method used in this thesis was an extensive literature review to widen the knowledge of current business model opportunities for additive manufacturing companies in the B2B area. The focus hereby lay by focusing first on finding as much aspects of business models relevant to additive manufacturing. The found aspects then were filtered by applicability to business-to-business.

The literature review showed clearly that there is practically no literature that is combining the three fields of additive manufacturing, business models and business-to-business companies. Therefore, a literature review that combines these three fields is enriching the scientific knowledge on one hand but also gives practitioners a better understanding of their environment in which they operate. It is essential to have a firm understanding of any field in order to do sound research. This work is providing the much-needed synthesis of all the fields required in order to develop successful business models for additive manufacturing companies. The tool was deliberately created in excel for easy accessibility to keep barriers of adaptation low. This was one of the key aspects when starting with the development.

The upside of using literature is that it allows to find diverse results in limited time. A literature review also builds on the existing knowledge of other researchers. As publishing of literature takes time it always has a lag. So as a downside it leaves out some very recent expertise of practitioners. This effect was countered by including business cases and use cases of additive manufacturing into the thesis. This way newer developments in the field of research can also be identified.

6.2 Results in context of research question

While most of the existing frameworks could be used to describe business models of B2B companies none of them is perfect. While the Business Model Canvas is a good tool to creatively design business models it lacks in guidance how a current successful B2B business model should look like. The St. Galler Business Model Navigator on the other hand is giving guidance on how business models could look like, but it is not very intuitive to design new ones with this framework and has downside on illustration part. The same downside is true for the Business Model Component Framework, which on the upside is giving a good overview what should be considered in a business model. The overarching shortcomings of all the reviewed frameworks were the lack of industry specific guidance. This is where this thesis tried to further the discussion by describing options for various positions in the value chain. With this framework businesses in different positions have orientation on how their business model could look like. This hopefully lowers the bar for managers and decision makers to explicitly describe their business models and by that improving their ways of doing business.

For the created framework it was stated that it should deliver the ability for self-evaluation, orientation, and allow for creative adaptability. The developed tool can be used to create an initial assessment of a company by answering just a few questions. While the provided business model from that questionnaire will probably not be the perfect fitting one it gives much-needed orientation. It is also intended to help organization navigating the market by giving the position in the value chain. The third characteristic creative adaptability is given by the use of the Business Model Canvas. The Business Model Canvas is known for its suitability for creative adaptation.

This means that the developed framework is able to fulfil all the required purposes. By combining all of the described characteristics it also improves on the existing frameworks, since none of the them was able to provide all of these dimensions.

7 Discussion and outlook

7.1 Summary

The goal of this thesis was to create a framework for describing the business models for businesses in the B2B market. The research question was specifically: “What is required of a framework to describe and evaluate business models of Additive Manufacturing companies in the B2B market?”

The thesis provides a self-assessment framework with which an additive manufacturing company operating in the B2B market can determine where they fit in the value chain. The framework was created in the following manner:

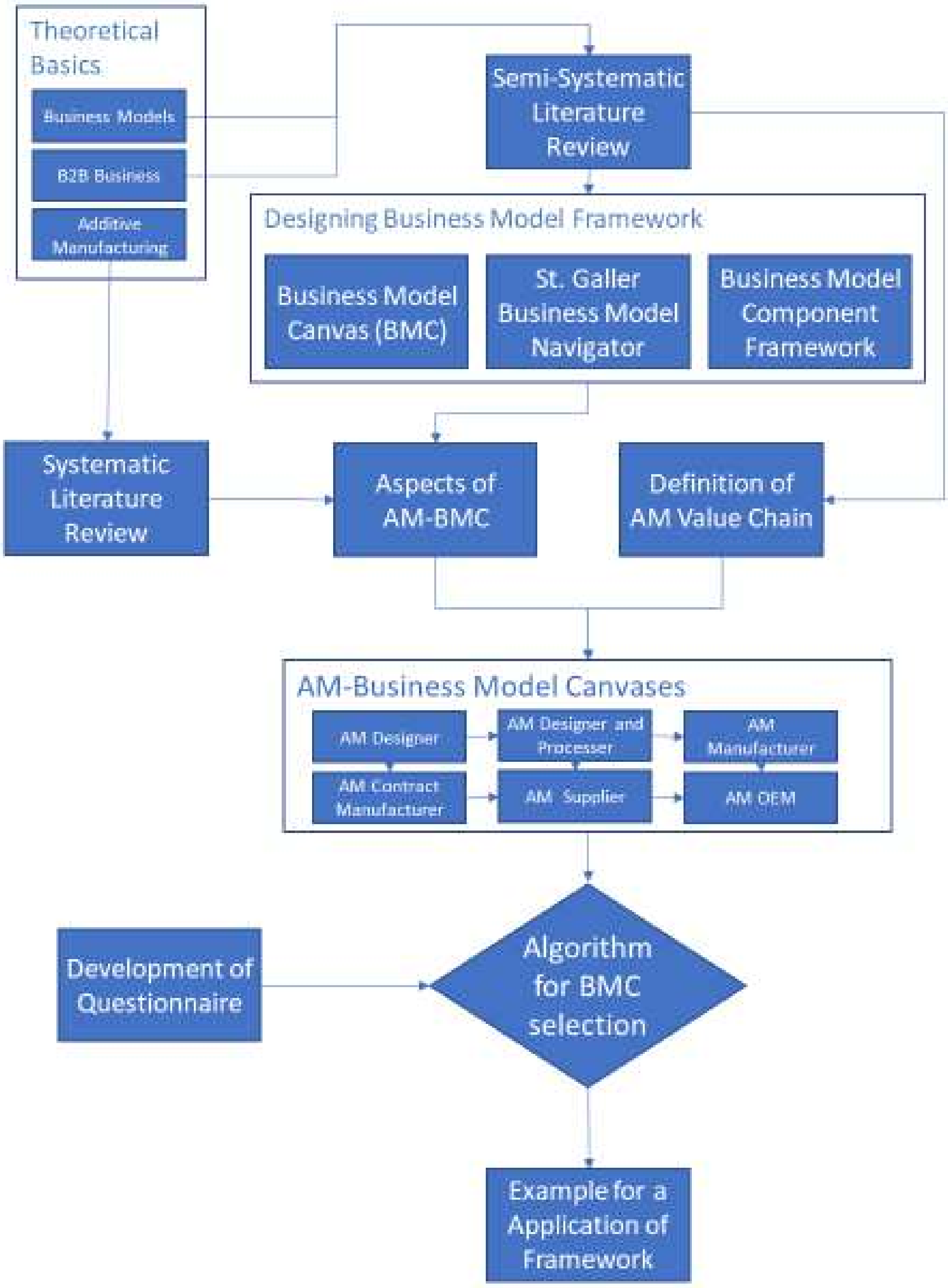


Figure 42: Conceptual Framework

With a systematic literature review of the topic business model the three Frameworks Business Model Canvas, St. Galler Business Model Navigator, and Business Model Framework are researched. In combination with research about B2B the findings about business models is used to create a definition of the AM Value Chain. The value chain of Additive Manufacturing exists of five steps which can be done independent from each other or in a combination:

- **Part Design:** Includes all steps necessary for designing of parts suitable for additive manufacturing
- **Pre-Processing:** The process of creating the digital input file for the production
- **Manufacturing:** Actual production of parts with additive manufacturing methods
- **Post-Processing:** None additive manufacturing activities necessary to make the product suitable for its purpose
- **Part-Assembly:** Assembling of different AM parts in to products

A systematic literature review about additive manufacturing with the knowledge generated in the existing framework analysis leads to the different aspects of an AM-Business Model Canvas. The aspects of an AM-BMC are then used to create together with the definition of the AM-value chain six business model canvases for different areas of the value chain. A questionnaire is then used to assess where a participant in the AM industry is situated in the value chain. According to the positioning in the value chain a different example framework is then created. This example framework shows the company the most important aspects and is the basis for further refinement.

Besides helping organizations to find their business model this framework is also intended to help research into business models in the additive manufacturing. The lack of documented business models is limiting the research in the field to find the most successful ones. By supplying practitioners with a simple tool to find their position in the value chain and then easily adapt their business model a higher number of business models will be available for research.

7.2 Limitations of approach and results

The fact that the six business models which are the basis for the framework are created from literature review only is probably the most significant limitation. Due to the newness of the field and the lack of a high number of business models operating in the additive manufacturing market it is not possible find the most successful at this moment. The business models are describing the possibilities more than they are best practices. This is a limitation that needs to be kept in mind when using the framework.

The point that this thesis was written in regard to B2B is limiting the specialty of used business models. While in the B2C world it seems possible that private customers will start printing small parts and objects at home soon, literature and case studies about current professional applications of additive manufacturing are not supporting this development in the B2B world. The reviewed literature focused mostly on internal production possibilities. New ways of distributing products through AM are rather an afterthought in literature at the moment. Here clearly is more research necessary.

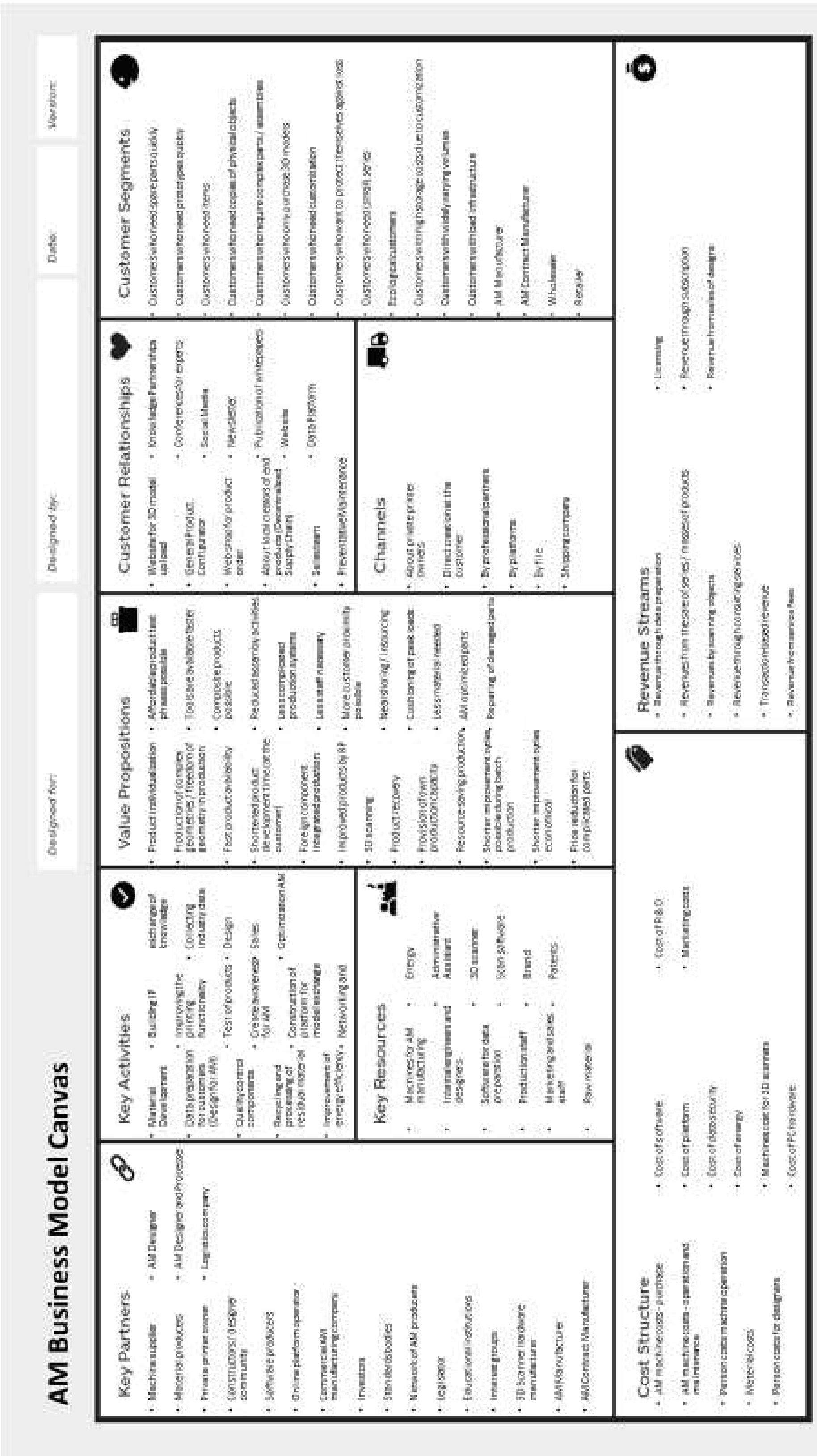
This work is not considering the wider changes to the production environment prophesied by many advocates of additive manufacturing, since applications of them are not yet documented in literature. While eventually the widespread adaption of 3D-printers and other AM technologies will revolutionize the manufacturing world, it has not happened yet and will probably not happen anytime soon. Therefore, home printing and other possibilities are considered niches which are not relevant for most B2B companies in the current environment.

7.3 Outlook

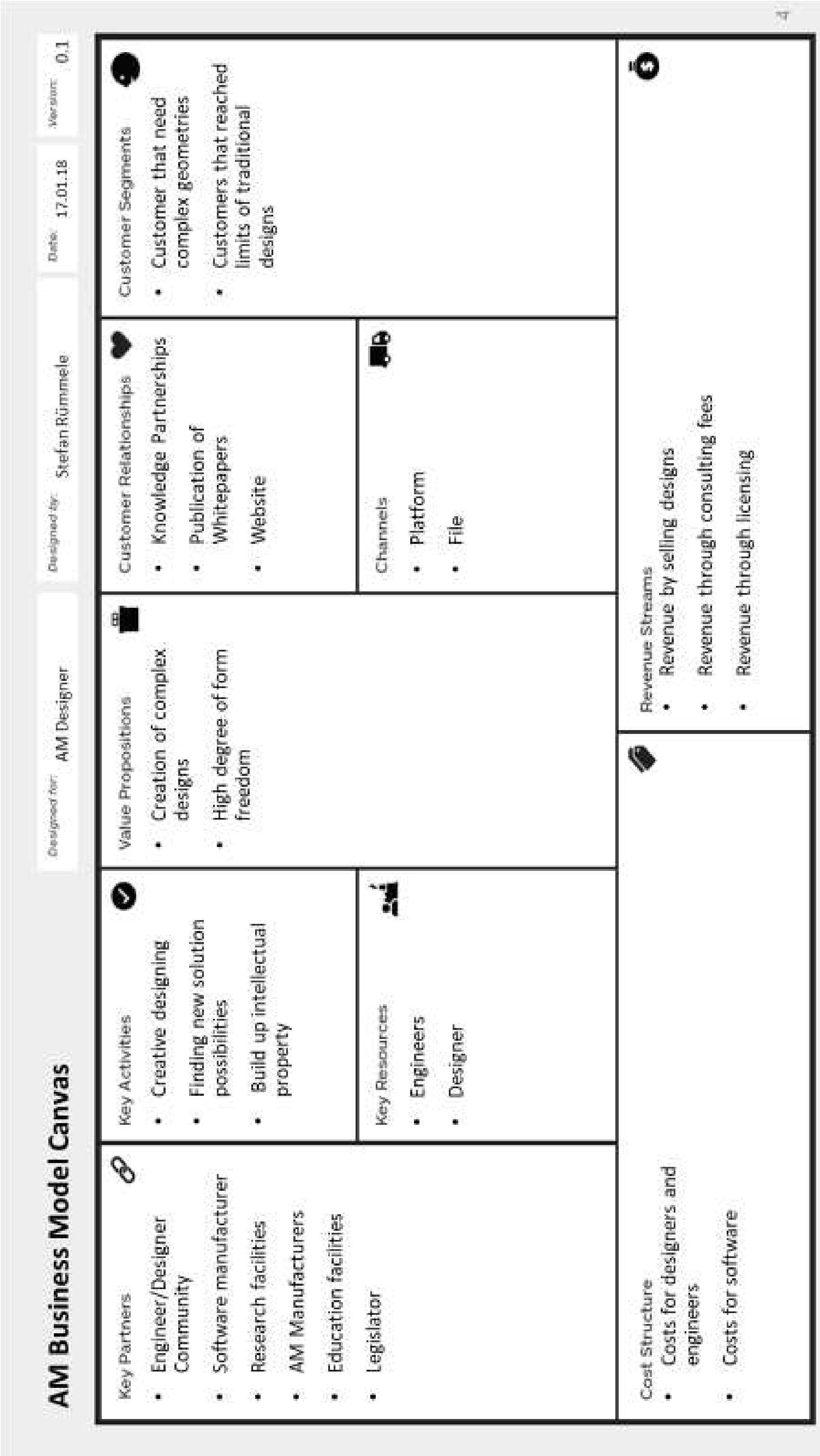
As intended in the overarching research project conducted by the Fraunhofer Institute the next step would be creating the best possible business models for additive manufacturing in the B2B market. The first step in doing this would be using the framework to create business models with real companies. This should be done in workshops where the here proposed framework is used to get a good orientation about the possible business models or in self-evaluation. The collected business models can then be used to evaluate what good business models are. How exactly the evaluation of successful business models needs to look like has to be answered in a different place. This probably could be the topic of another thesis. In regard to the here developed framework the adaptations of the basic business models created throughout a workshops and self-evaluation can be used to update the ones in this framework. There should be continuous evaluation of the proposed business models of the framework. The field of business models is constantly evolving, and it is easily possible that while this is written someone is developing a new business model or is evolving parts of it, which could be applicable for additive manufacturing. Such new business model ideas need to be fed to the framework to keep it up-to-date and therefore relevant. Feedback from interviews should also be used to improve the questions in the questionnaire. The more accurate the questionnaire is identifying the correct place in the value chain, the more value it can generate by increasing the knowledge of what. This knowledge gain hopefully drives adaptations of the whole framework which in turn would increase the quality of the proposed business models.

8 Appendix

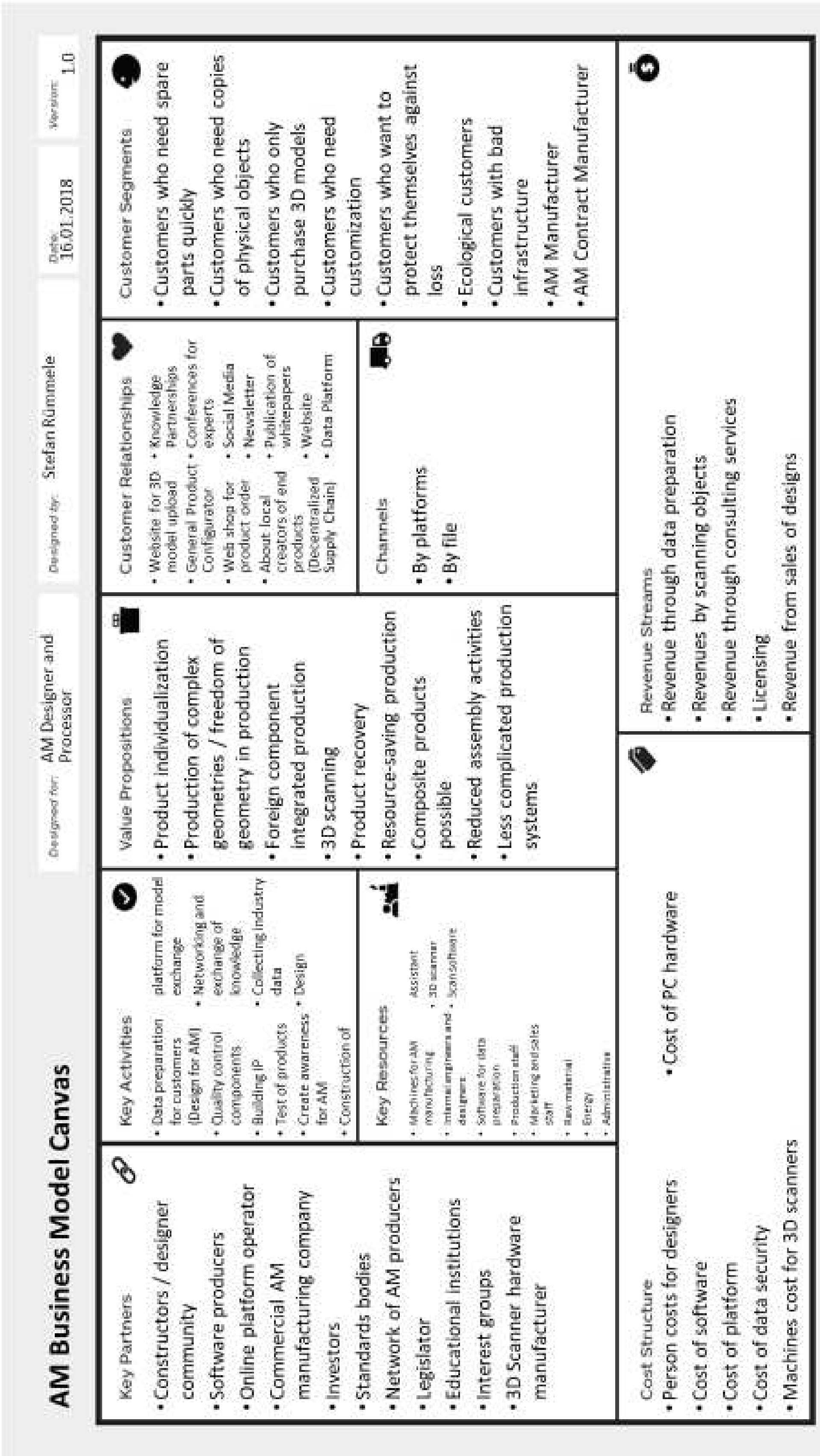
8.1 Aspects of the AM Business Model Canvas



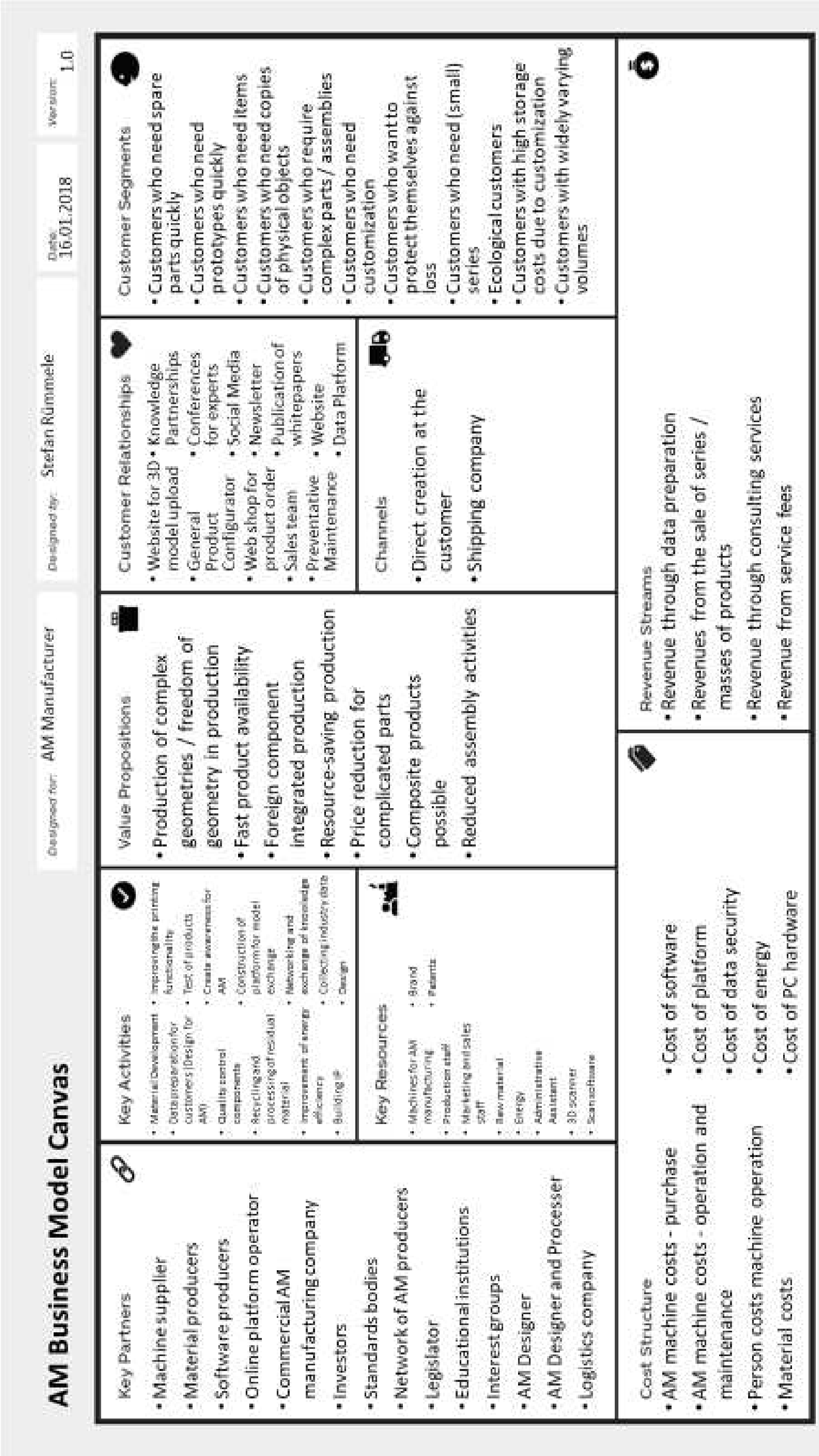
8.2 AM Designer Business Model Canvas



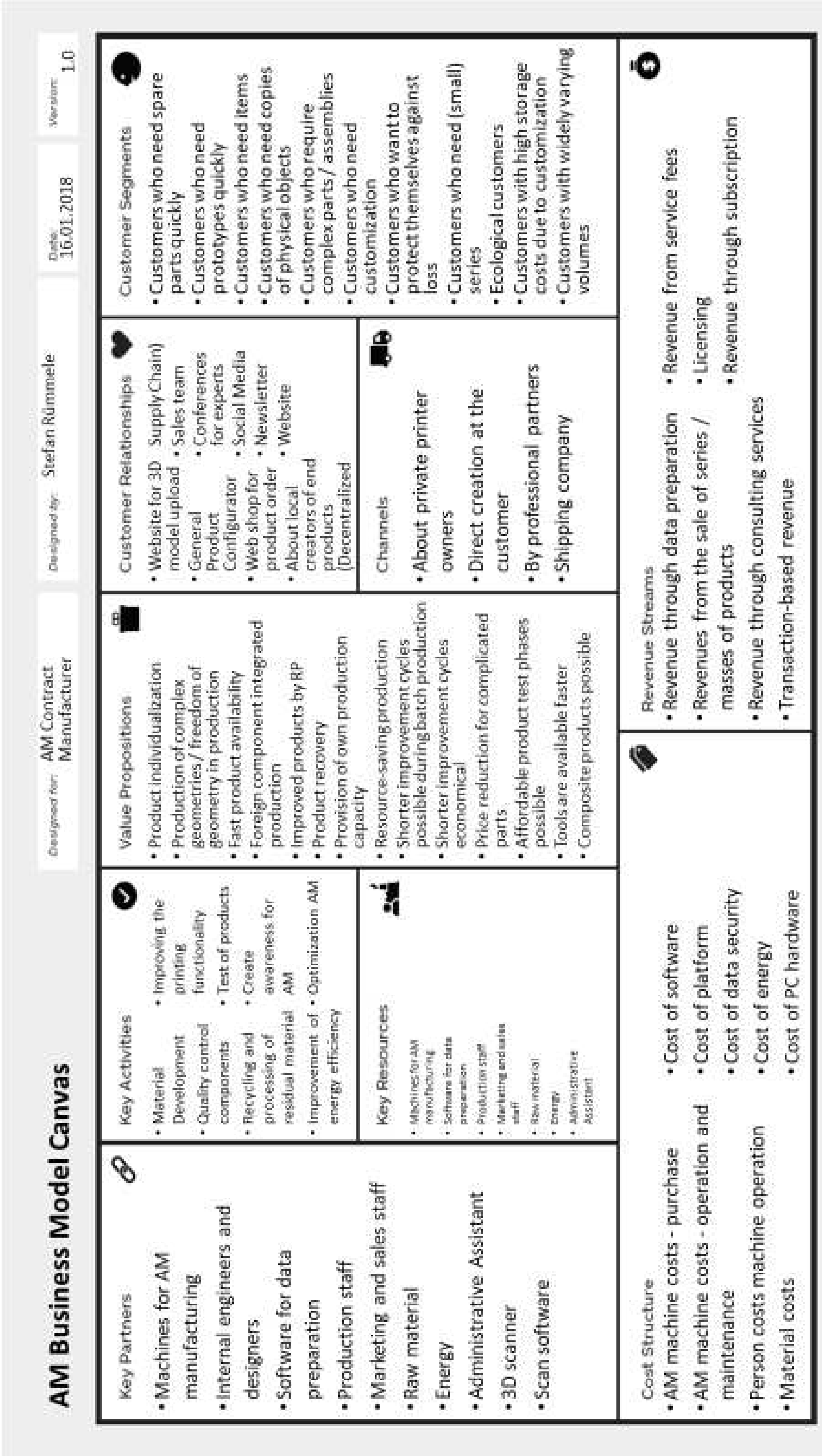
8.3 AM Designer and Processor Business Model Canvas



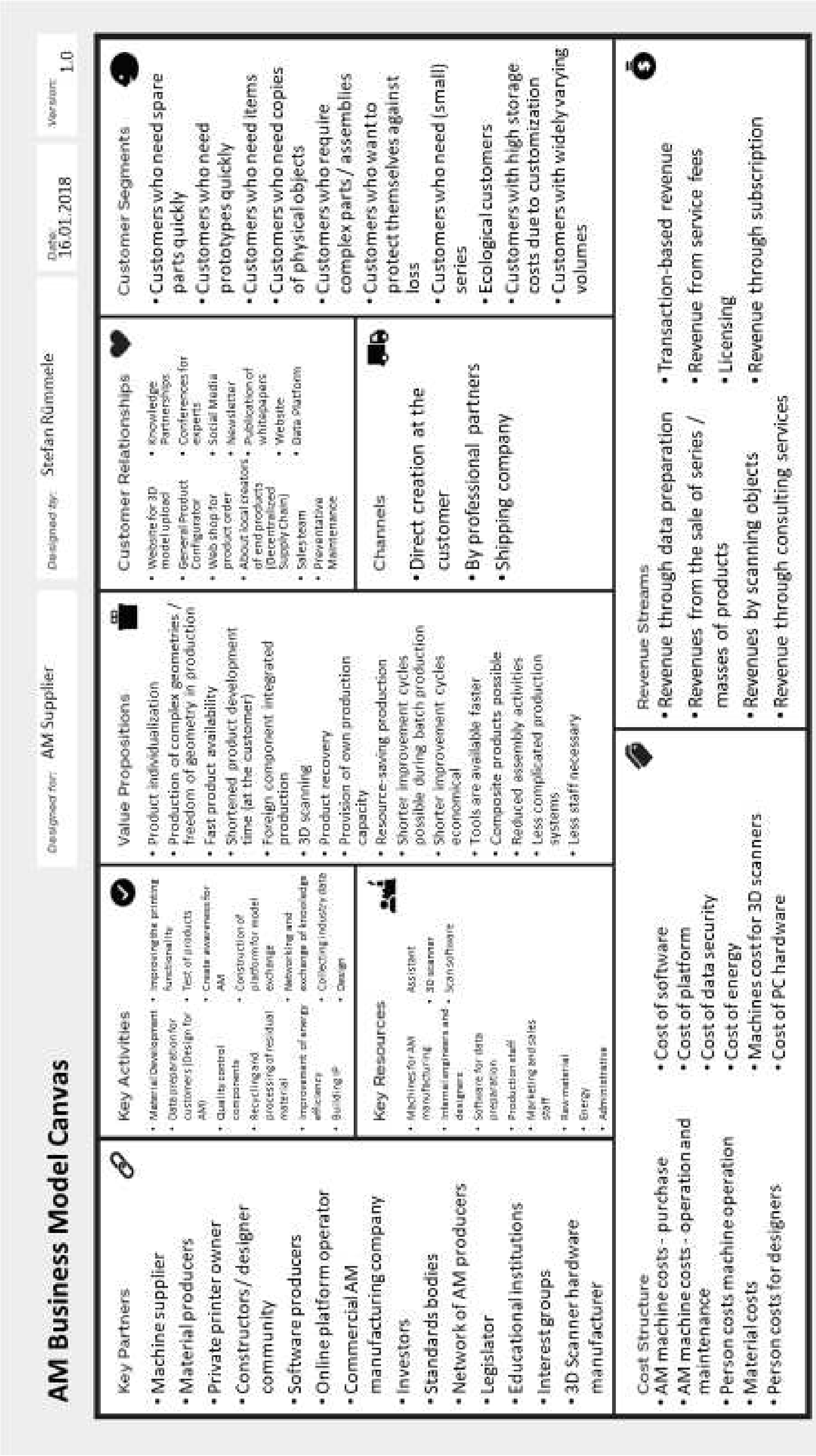
8.4 AM Manufacturer



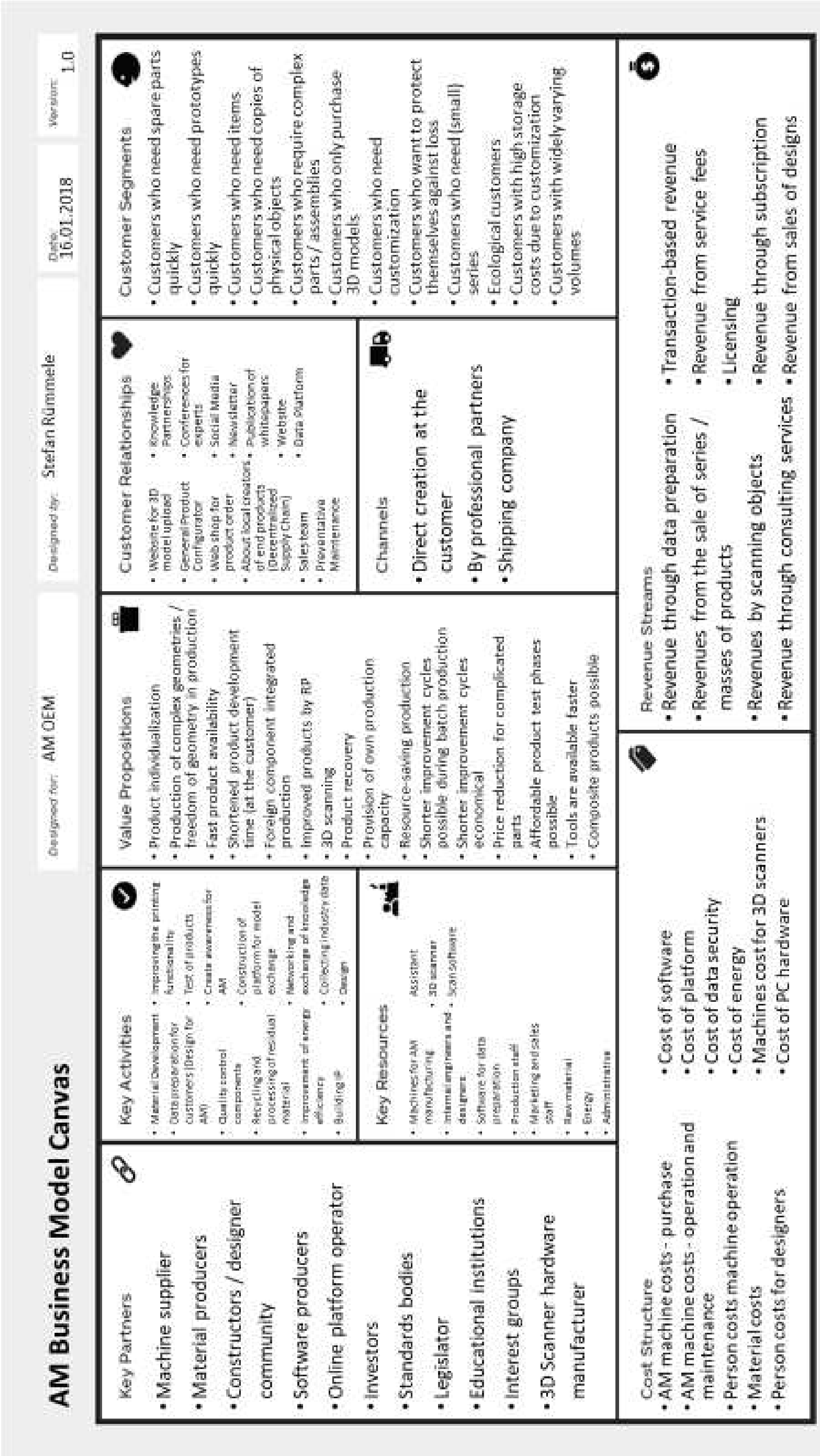
8.5 AM Contract Manufacturer



8.6 AM Supplier



8.7 AM OEM


AM Business Model Canvas
Designed for: AM OEM
Designed by: Stefan Rümmele
Date: 16.01.2018
Version: 1.0
Key Partners
• Machine supplier
• Material producers
• Constructors / designer community
• Software producers
• Online platform operator
• Investors
• Standards bodies
• Legislator
• Educational institutions
• Interest groups
• 3D Scanner hardware manufacturer
Key Activities
• Material Development
• Data preparation for customers (Design for AM)
• Quality control components
• Recycling and processing of residual material
• Improvement of energy efficiency
• Building IP
• Improving the printing functionality
• Test of products
• Create awareness for AM
• Construction of platform for model exchange
• Networking and exchange of knowledge
• Collecting industry data
• Design
Key Resources
• Machines for AM manufacturing
• Internal engineers and designers
• Software for data preparation
• Production staff
• Marketing and sales staff
• Raw material
• Energy
• Administrative Assistant
• 3D scanner
• Scan software
Value Propositions
• Product individualization
• Production of complex geometries / freedom of geometry in production
• Fast product availability
• Shortened product development time (at the customer)
• Foreign component integrated production
• Improved products by RP
• 3D scanning
• Product recovery
• Provision of own production capacity
• Resource-saving production
• Shorter improvement cycles possible during batch production
• Shorter improvement cycles economical
• Price reduction for complicated parts
• Affordable product test phases possible
• Tools are available faster
• Composite products possible
Customer Relationships
• Website for 3D model upload
• General Product Configurator
• Web shop for product order
• About local creators of end products (Decentralized Supply Chain)
• Sales team
• Preventative Maintenance
• Knowledge Partnerships
• Conferences for experts
• Social Media
• Newsletter
• Publication of whitepapers
• Website
• Data Platform
Channels
• Direct creation at the customer
• By professional partners
• Shipping company
Customer Segments
• Customers who need spare parts quickly
• Customers who need prototypes quickly
• Customers who need items
• Customers who need copies of physical objects
• Customers who require complex parts / assemblies
• Customers who only purchase 3D models
• Customers who need customization
• Customers who want to protect themselves against loss
• Customers who need (small) series
• Ecological customers
• Customers with high storage costs due to customization
• Customers with widely varying volumes
Cost Structure
• AM machine costs - purchase
• AM machine costs - operation and maintenance
• Person costs machine operation
• Material costs
• Person costs for designers
• Cost of software
• Cost of platform
• Cost of data security
• Cost of energy
• Machines cost for 3D scanners
• Cost of PC hardware
Revenue Streams
• Revenue through data preparation
• Revenues from the sale of series / masses of products
• Revenues by scanning objects
• Revenue through consulting services
• Transaction-based revenue
• Revenue from service fees
• Licensing
• Revenue through subscription
• Revenue from sales of designs

8.8 Questionnaire options

Group	Anticipated Answer	Weighting	Active Questions	Active Answer Options	Planning Questions	Planning Answer Options
Design	Company creates creative designs themselves	3	How important is creativity for you when hiring new designers?	0 - N/A;1 - Creativity is not important;2 - Creativity is not very important;3 - Creativity has some importance;4 - Creativity is important;5 - Creativity is most important	How interested are you in creating your own designs?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Design	Company creates 3D scans of items	2	How important is your company to create 3D scans?	0 - N/A;1 - Not Important;2 - Slightly Important;3 - Moderatly Important;4 - Important;5 - Very Important	How interested are you in creating 3D scans?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Design	Company examines existing designs on AM fitness	1	How important are reviews of designs for AM suitability for your company?	0 - N/A;1 - Not Important;2 - Slightly Important;3 - Moderatly Important;4 - Important;5 - Very Important	How interested are you in testing good designs for AM-fitness?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Design	The company optimizes existing designs for AM capability	2	How is high the potential for existing designs for adaptation for AM?	0 - N/A;1 - No Potential;2 - Low Potential;3 - Some Potential;4 - High Potential;5 - Very High Potential	How interested are you in optimizing existing designs for AM?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Pre-Processing	Company creates its own STL files	3	How many of the STL-files currently in use did your company create?	0 - N/A;1 - None; 2 - Around 25%;3 - Around 50%;4 - Around 75%;5 -100%	How interested are you in creating STL files?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Pre-Processing	Company checks STL files for correctness	2	How often do you check STL-files for other businesses?	0 - N/A;1 - Never; 2 - Seldome;3 - Sometimes;4 - Often;5 - Almost all the Time	How interested are you in checking the existence of STL files for correctness?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Pre-Processing	In order for generated parts to meet the requirements, build parameters must be determined internally.	1	How important is your company's definition of build parameters?	0 - N/A;1 - Not Important;2 - Slightly Important;3 - Moderatly Important;4 - Important;5 - Very Important	How interested are you in setting the build parameters?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Pre-Processing	Externally finalized STL files often do not meet the specific requirements.	1	How important is your company to finalize STL files?	0 - N/A;1 - Not Important;2 - Slightly Important;3 - Moderatly Important;4 - Important;5 - Very Important	How much are you interested in finalizing STL files?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested

Manufacturing	The definition of machine parameters is a core competence of every GF company.	2	How important is it for your company to determine the machine parameters themselves?	0 - N/A;1 - Not Important;2 - Slightly Important;3 - Moderatly Important;4 - Important;5 - Very Important	How much are you interested in defining the machine parameters yourself?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Manufacturing	The actual production of parts is the most interesting part of GF.	3	How high is your AM manufacturing expertise ?	0 - N/A;1 - Very Poor;2 - Below Average;3 - Average;4 - Above Average;5 - Excellent	How interested are you in the actual production of parts?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Manufacturing	The improvement of production methods leads to advantages in the market	1	How often do you improve your manufacturing method in the last year?	0 - N/A;1 - Never;2 - Once;3 - Twice;4 - Four times;5 - 5 Times Or More	How much are you interested in improving production methods?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Manufacturing	Monitoring processes is important for companies	2	How many process parameters are you tracking?	0 - N/A;1 - None;2 - Up to 10;3 - Up to 20;4 - Up to 30;5 - More than 30	How much are you interested in controlling the production process?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Manufacturing	The process of removal from the machine offers great potential for optimization.	1	How high is the level of automation for the removal of parts from the AM machine	0 - N/A;1 - Completly Manual;2 - Mostly Manual;3 - Half-Half;4 - Mostly Automated;5 - Completly Automated	How much are you interested in the process of removal from the machine?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Post-Processing	Company tests produced parts	1	How high is the percentage of parts controlled with methods like ultrasound, CT, etc.?	0 - N/A;1 - None; 2 - Around 25%;3 - Around 50%;4 - Around 75%;5 -100%	How much are you interested in controlling produced parts?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Post-Processing	Company performs heat treatment on produced part	3	How high is the percentage of heat treated AM parts?	0 - N/A;1 - No parts were heat treated; 2 - Around 25%;3 - Around 50%;4 - Around 75%;5 - All parts were heat treated	How interested are you in the heat treatment of produced parts?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Post-Processing	Company removes remaining features of parts	2	How often must features be removed from parts?	0 - N/A;1 - Never; 2 - Around 25%;3 - Around 50%;4 - Around 75%;5 - Everytime	How much are you interested in removing other features after making parts?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Post-Processing	Company performs surface treatment such as sanding, polishing, etc.	3	How many different surface treatmens are you performing?	0 - N/A;1 - None;2 - One;3 - Two;4 - Three;5 - More Than Three	How interested are you in the surface treatment of created parts?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested

Application	Company builds parts in assemblies	2	How high is the percentage of AM parts in your finished moduls?	0 - N/A;1 - No assembly of moduls with AM parts; 2 - Around 25%;3 - Around 50%;4 - Around 75%;5 - Modul consist only of AM parts	How interested are you in producint moduls from AM parts?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Application	Company builds parts ready parts	2	How high is the percentage of AM parts in your finished products?	0 - N/A;1 - No assembly of moduls with AM parts; 2 - Around 25%;3 - Around 50%;4 - Around 75%;5 - Product consist only of AM parts	How interested are you in producing products from AM parts?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested
Application	Company uses parts as a means of production	2	How suitable are AM made manufacturing inputs for your production	0 - N/A;1 - Not Suitable;2 - Somewhat Suitable;3 - Moderatly Suitable;4 - Suitable,5 - Highly Suitable	How interested are you in using AM parts as manufacturing inputs?	0 - N/A;1 - Not Interested At All;2 - Not Interested;3 - Somewhat Interested;4 - Interested;5 - Very Interested

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10 Table of figures

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12 Glossary

B2B	Business to Business
B2C	Business to Customer
etc.	et cetera
h	Stunde
sh.	siehe
u./o.Ä.	und/oder Ähnliche/s
z.B.	zum Beispiel