Future of Fashion

Exploring the potential for industrializing custom-made apparel

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Abstract

The fashion industry is undergoing rapid transformation due to trends such as uncertainties in international trade, technological advances and changing customer preferences. One such preference is an increasing demand for custom-made apparel, to which actors in the industry will have to adapt.

The increased emphasis on custom-made apparel is expected to bring a number of challenges that will need to be overcome. This thesis both identifies, as well as clarifies reasons behind such challenges. Additionally, opportunities expected to arise in this changing environment are explored. The linking together of these areas intended to address and fulfill the overall project purpose, which was to analyze challenges and opportunities in industrializing custom-made fashion.

The project was conducted as a case study, in which custom-made products in the fashion industry were investigated. Two main sources of data were used to lay a foundation for the thesis. The first one was a literature study, where existing knowledge was extracted from books, articles and industry reports. The second source of data was interviews conducted in a semi-structured manner with industry professionals. Frameworks from the literature study were applied to insights from the interviews in order to form analysis and draw conclusions.

The project reveals automating apparel production to be highly complex and the readiness to scale such production to be low. Thus, the location of the majority of apparel production today driven by two factors. Firstly, where production labor cost were considered as cheap. Secondly, where labor skills meet set quality requirements. Even though fashion players were positive to new technology and addressing was a need for custom-made apparel, there was a common view of risk of being a first mover with new technology.

New business opportunities for existing but also new players emerge given that custom-made apparel manufacturing will be industrialized. To mention a few, measuring combined with increased customer experience was predicted to become prominent business area. Given the scenario that body scanning will take on a role in the manufacturing process of apparel, data management players are also likely to emerge.

Keywords: Custom-made fashion, sustainability, operations strategy, lean operations, agile operations, augmented reality, omni-channel, data management, pull strategy, retail strategy.

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Emil Gleerup & Max Modig

Gothenburg, January 2019

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Terminology & Abbreviations

- **Agile** - Business approach that facilitate working flexibly.
- **Bulk production** - Production of products that is not customer customer specific, often made to stock.
- **BOM** - Bill of material. List used for manufacturing including all components needed to finalize a product.
- **CAGR** - Compound annual growth rate.
- **CODP** - Customer order decoupling point.
- **Customization** - Process where customer influences on product features.
- **E-commerce** - Online sales channel where purchase of apparel is made.
- **Fashion industry** - Holistic fashion industry view, including players for design, manufacturing and end-use of apparel industry.
- **Lean** - Business development ideology aimed to minimize waste through different initiatives.
- **Nearshoring** - Outsourcing taking place near end market.
- **Omnichannel** - Cross-channel strategy utilized to support cooperation between channel functions.
- **On-demand manufacturing** - Manufacturing that starts at the moment when an order is confirmed.
- **RFID** - Radio-frequency identification technology.
- **Tailor-made manufacturing** - Process where apparel is made to customer specific measures.

1
Background

This chapter presents how and why this project was initiated. It includes a motivation for executing the project and an introduction to the firm with which it is carried out.

1.1 Project Background

This master's thesis project is carried out in collaboration with the Gothenburg based firm The Techno Creatives. The firm is specialized in defining and developing products with strong digital and customer focus. It does this through its three business areas: exhibitions & demos, tech exploration & innovation and ventures & startups. To present a few of its endeavors, The Techno Creatives has previously developed several smartphone applications and an augmented wrist watch. The watch is analog, but has the ability to stream data from a digital source through a smartphone and visualize it on the hands.

In parallel to its ventures, The Techno Creatives runs an innovation consulting business that has several global top clients in a variety of industries (The Techno Creatives, 2018). Here, the firm defines and develops digital products that comprises hardware and software. Their success within this business is driven by their know-how in design and a strong focus on user experience among other things.

The motive behind the project at hand was to explore the feasibility of a new retailing concept, where mass customization potentially can address challenges in the changing industry environment, presented in Customer Preferences (section 2.3). This retailing concept aims to offer industrially manufactured custom-made apparel. Anticipated benefits of this include mitigating over-production as well as the high rates of item returns currently characterizing the fashion industry. The Techno Creatives wants to enable this by making production more demand driven by using technology to involve customers in the designing and customization of garments, and thereby enhance the shopping experience. This could potentially reduce uncertainty that is currently making to customers return their products at an increasing rate. Together, these steps could lead to financial advantages which could attract interest from current players in the fashion industry. More specifically, the firm expects to lower production costs by reducing waste, as well as setting a higher market price and contributing to sustainability improvements through the customization.

Because of the changing fashion business condition, presented in Operations Strategy (section 4.3), and increased influence of technology, The Techno Creatives anticipates that opportunities could emerge for a technology pioneer like itself. Thus, the project also aims to identify potential opportunities for existing and new stakeholders in the fashion business.

2 Introduction

The fashion industry is undergoing rapid transformation (Hagberg et al., 2016). This can be attributed to several causes, including uncertainties in international trade, increasing conversion to mobile platforms and heightened sustainability concerns among consumers (Keller et al., 2014). In this dynamic landscape, flexibility and willingness to adapt become key means of competition (Christopher, 2000).

Against this backdrop, it becomes clear that firms can not afford to be stagnant, but must constantly be on the lookout for new, innovative ways of conducting business in order to stay competitive. An example of this could be the retail concept devised by The Techno Creatives that evoked the initiation of this project, as presented in chapter 1.

To enable thorough evaluation of a new concept within the fashion industry, one must first familiarize oneself with the structures and trends of the industry. Thus, this chapter will outline several such elements, with industry reports providing a basis for most of the presented data. The information presented provides key industry insights in fashion that will lay a foundation for subsequent chapters in the report.

2.1 Sustainability Concerns

Fashion is reportedly one of the most polluting industries in the world (Danish Fashion Institute, 2013). This environmental footprint includes high water consumption, generation of waste and emissions of hazardous chemicals (Amed et al., 2017). Moreover, the industry also struggle with lacking social standards such as violations against human rights and low workplace standards (Ibid.). This development has a notable effect on consumer awareness, with observations made by Keller et al. (2014) showing that sustainability is becoming an increasingly important aspect for customers within the fashion industry globally (Ibid.). However, while most customers expect criteria such as ecological fabrics, reduced emissions and fair working conditions to be met, few are willing to pay more for it, according to reports by Keller et al. (2014). Contrarily, Kruh et al. (2018) find that 66% of customers globally are ready to pay more for products from sustainable brands, where millenials are expressing the strongest sustainability concern at 73% of respondents.

Lehmann et al. (2018) evaluate multiple steps in the value chain of the global fashion industry based on key environmental and social impact areas. These steps are shown in figure 2.1 and described further below. While measures such as new materials and improved resource efficiency are steps in the right direction, they are not enough to satisfy the need for long-term sustainability (Ibid.). Instead, it is disruptive innovation, such as application of elements of industry 4.0, that foretells a sustainable future (Ibid.). Also, a collective effort in collaboration and coordinating is required from stakeholders to enable environmental sustainability in the fashion industry (Ibid.).

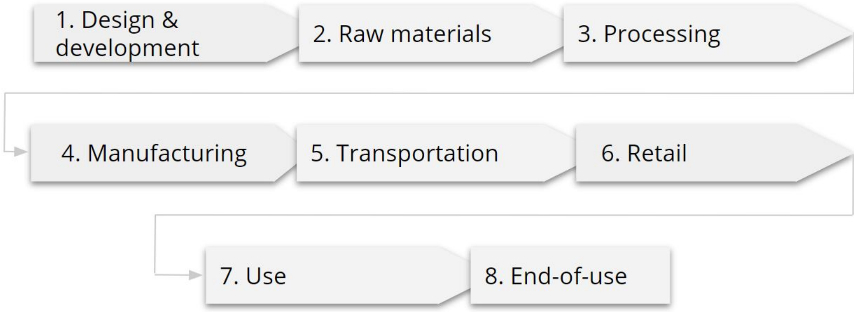

Figure 2.1: The figure visualizes activities included in the fashion value chain (Lehmann et al., 2018).

The design and development phase corresponds to two-thirds of the total environmental impact of the fashion industry and is crucial, considering it affects all the ensuing steps in the value chain (Lehmann et al., 2018). There are positive trends in this area, with Hugo Boss opting to stop making physical samples for its 2018 pre-fall collections in favour of digital showrooms as an example (Ibid.). Moreover, Inditex is committed to train all of their designers on circular design principles by 2020, which is another sustainability effort (Ibid.).

While there is progress being made, Lehmann et al. (2018) emphasize that the amplitude of sustainability in the industry will be limited as long as no new scalable material solutions exist. In this aspect, small, low-price actors typically score the worst, considering their lack of knowledge and control over suppliers, while sportswear and outdoors companies are pioneers thanks to their high levels of investments in innovative materials (Ibid.). Lehmann et al. (2018) highlight the trade-offs characterizing materials used today. For example, synthetic fibers like polyester require less water than cellulose fibers and are more durable, but on the other hand shed plastic microfibers during use (Ibid.).

It is during processing that the combined environmental impact of water, energy, waste and chemicals is the largest, yet few companies include this stage in their sustainability efforts (Lehmann et al., 2018). Processing is also one of the most advanced steps (together with manufacturing and transportation), and includes activities such as cotton farming and dying which requires significant amounts of water and chemicals (Ibid.).

Behind raw materials, manufacturing is placed second on the list of value chain activities prioritized by companies in a business health study, focusing on sustainability opportunities (Lehmann et al., 2018). Important progress here includes measures to improve working conditions for employees, which also can be beneficial from a financial standpoint (Ibid.). For example, the Indian textile manufacturer Arvind has seen a halving in accident frequency and man-days lost over a two-year period after implementing improved safety features (Ibid.). Steps to further enhance sustainability in manufacturing include innovations that enable higher degree of automation, and solutions enabling customization of apparel on a large scale, for example through the use of body scans (Ibid.).

The study by Lehmann et al. (2018) shows transportation being the least prioritized value chain step among companies, but many nonetheless score well in this respect. For example, Hugo Boss has managed to reduce their emissions by 95% through adjusting routes and means of transportation, opting to ship less by air and more by rail and sea (Ibid.).

Retailing is another important step in the value chain, as innovation in the industry requires collaboration between retailers, brand owners and manufacturers to reach sufficient growth (Lehmann et al., 2018). Examples of retailing solutions that could enhance sustainability within the industry include technology to allow greater customization of garments (Ibid.). Also, applying augmented reality technology could increase the customer experience such as creating digital fitting rooms (Ibid.).

End-of-use is the value chain step where companies are improving the fastest, although it is also the step where the level of sustainability is the lowest (Lehmann et al., 2018). Innovations such as using RFID tags in apparel to provide information about materials used and facilitate recycling give hope of further improvement (Ibid.). Lehmann et al. (2018) emphasize the need for suppliers, investors, regulators, consumers and other actors to join forces and create an ecosystem that supports transformational innovation in this area, since no company can overcome the challenges in end-of-use alone.

One example of such collaborative efforts is H&M, which collects used garments, no matter brand and condition, in their stores from customers (Group, 2018). These clothes are later being re-used instead of ending up as landfill, which is often the case. In 2017, H&M managed to collect almost 18 tons of garments (Ibid.). In return, customers get discounts when purchasing new garments (Ibid.).

A second example is an independent fashion player called The Renewal workshop. This actor exclusively focuses on repairing flaws of garments to reduce landfills and excess inventory (Fox, 2018). When garments are restored, they are either sold back to the retailers or directly to customers (Ibid.).

2.2 Retail Channels

While e-commerce is no novelty in 2018, there is still ongoing digital convergence in the sense that customers are increasingly using online platforms for the complete purchasing process (Keller et al., 2014). This increases the demand for usability in e-commerce, and requires retailers to integrate their offline and online offerings to a larger extent rather than running them separately (Verhoef et al., 2015). This phenomenon is referred to as omnichannel retailing (Ibid.). This leads to a blur of the distinction between online and offline, and demands of offline retailers to ask themselves questions such as whether a physical store is expected to drive sales and generate profit by itself, or if it to a larger degree is to act as a brand ambassador supporting online sales (Keller et al., 2014). The importance of such questions become clear when looking at figure 2.2, which shows tremendous growth in web-influenced offline purchases of apparel.

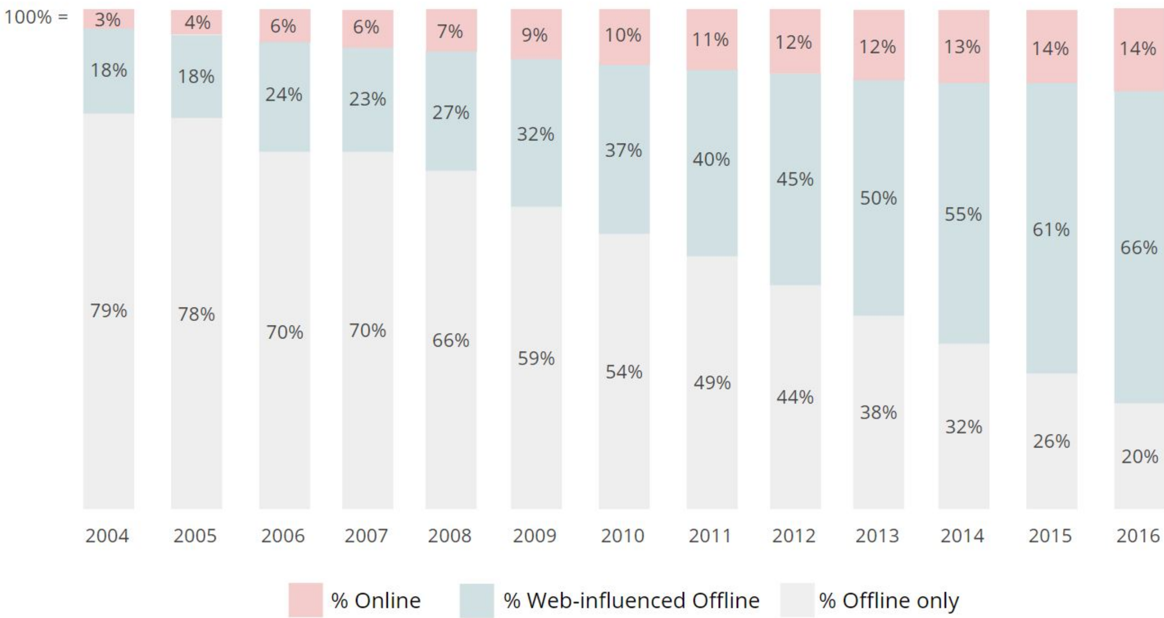

Figure 2.2: Apparel retail sales by type in the United States from 2004-2010, and estimates for 2011-2016 (Statista, 2012).

There is plenty of other data that further highlights the significance of online retail. While the growth of online sales as a percentage of total sales, as shown in figure 2.3, is relatively small, a strong growth is more evident when looking at figure 2.4, which shows the revenue from online sales year-on-year.

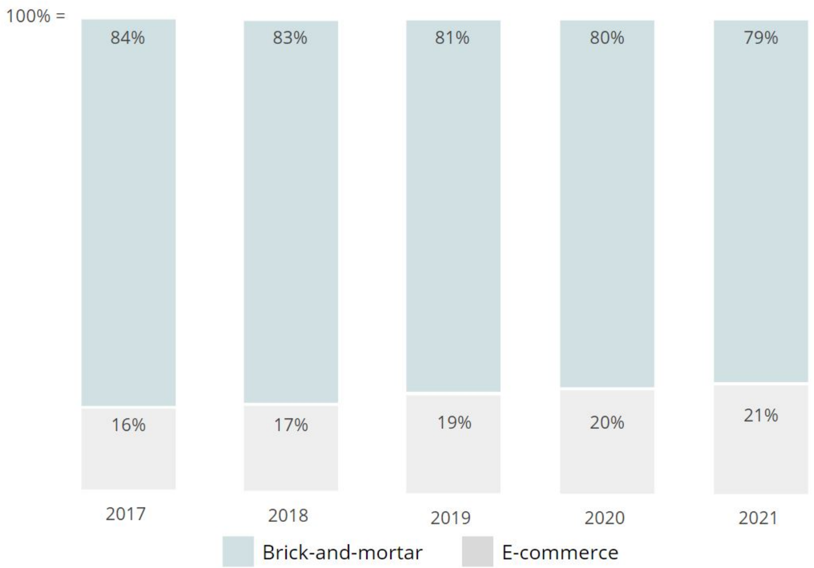

Figure 2.3: Segmentation of apparel revenue in online- offline channels in the European market (Statista, 2018).

There are numerous drivers behind this strong increase in apparel online sales. Bohnhoff (2016) presents a broader selection of products in online stores, free shipping, improved delivery and return processes as important factors attracting customers. Kruh (2017) ranks the ability to shop around the clock, the ability to compare attributes, and the chance of finding better deals as the three most common reasons consumers shop online rather than in stores.

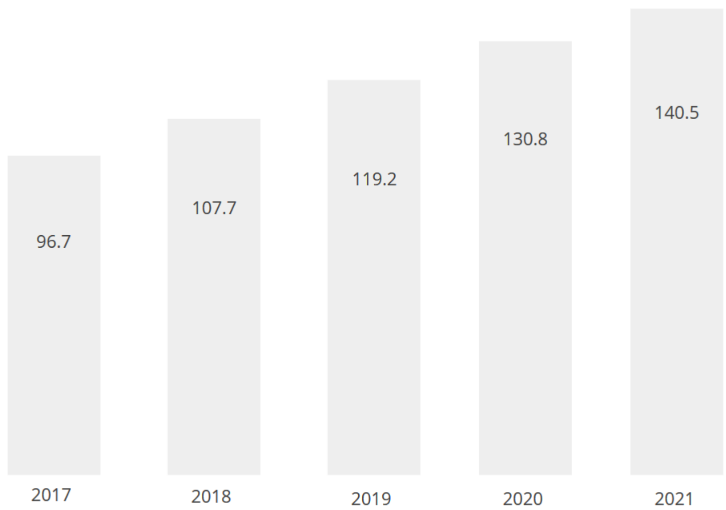

Figure 2.4: Online revenue from fashion in the European market, in billion US dollars (Statista, 2016).

According to Amed et al. (2018), emerging markets are key drivers behind the online market growth. For example, the Southeast Asian population spends eight hours per day online (Ibid.). A big portion of this online activity can be attributed to smartphone use, which is important to note since Bohnhoff (2016) names mobile shopping among trends that will shape the industry in the coming years. Two-thirds of the world's 45 e-commerce unicorns stemming from Asia further emphasize the impact emerging markets have on online sales (Amed et al., 2018).

2.3 Customer Preferences

The new fashion business climate is not only experiencing shifting habits regarding what to purchase, but also where to purchase. A study by Berg et al. (2015) aiming to identify critical factors when transitioning from single channel to omnichannel showed significant differences in consumer behaviour and preferences between offline and online channels, as shown in figures 2.5 and 2.6. It can be noted that while product fit is the most important aspect for both categories of customers, the brand aspect is relegated by online customers in favour of website usability and delivery and collection. Kruh (2017) note that the three most common reasons for consumers to shop in physical stores rather than online are the ability to see and touch the item before buying, the ability to try it on, and concern over whether the product looks different in real life compared to the pictures online.

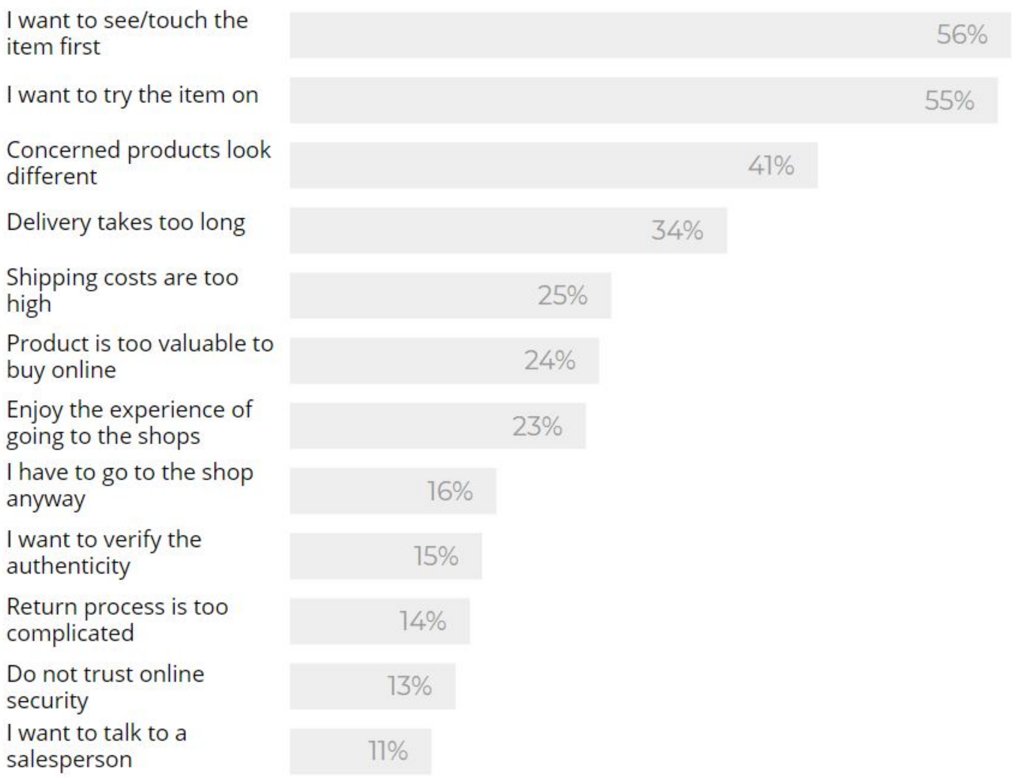

Figure 2.5: List of criteria that appeal to offline customers (Berg et al., 2015).

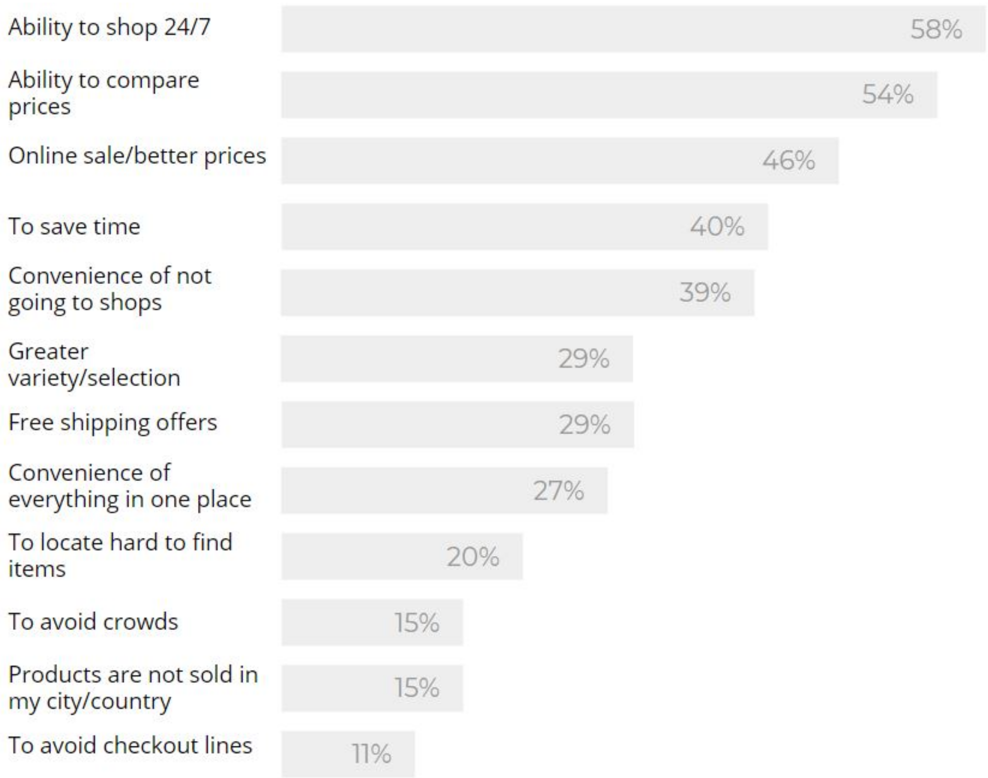

Figure 2.6: List of criteria that appeal to online customers (Berg et al., 2015).

Furthermore, (Keller et al., 2014) highlight two other fashion industry trends. The first one is that the shopping experience will become increasingly important to customers (Ibid.). According to Kruh et al. (2018), *experience per area unit* will overtake as the most important metric for retailers by 2020. As an example, the shopping experience can be improved by offering increased possibilities for product customization. Two industry examples are Nike and Ulta Beauty, who have managed to enhance shopping experience by further engaging their customers in the shopping process. Ulta Beauty offers beauty treatments to make their visiting customers stay longer in the store (Kruh et al., 2018). Nike offers customization of shoes by allowing customers to choose colors and to add his or her name to the shoe (Nike, 2018). A second trend emphasized by Keller et al. (2014) is mobile devices playing an even bigger role for retail in the future. Already, about half of China's online purchases are done via phone (Keller et al., 2014).

In a study conducted by Oghazi et al. (2018), the business impact of return leniency is investigated. Here, a lenient return policy is described as an increase of trust from e-commerce companies to the consumers. Since customers are given the option to send back orders free of charge, e-commerce firms are taking a risk (Oghazi et al., 2018). In Sweden, customers may return a product within 14 days (Konsumentverket, 2018). However, this does not apply to custom-made products (Ibid.).

Lenient return policies impact a variety of factors in the purchase process. Oghazi et al. (2018) show that lenient return policies do not only increase the frequency of orders, but also return rates. Additionally, they decrease single item value and order value in total (Ibid.). Thus, the long term net impact of poorly designed return policies can be costly (Ibid.). Furthermore, as the more environmentally aware millennial population is growing, the importance of ethical aspects becomes more critical for fashion players to meet (Ibid.). An evidence of this concern is that consumers are willing to pay more for sustainable products (Ibid.).

Interestingly, Hjort and Lantz (2016) also argue that even though e-commerce companies have great access to market data, it is utilized only to a minor extent. As a result, firm's return strategies are not appropriately designed to maximize profitability (Ibid.). A case study conducted by Hjort and Lantz (2016) reveals that organizations might not benefit from their current lenient return policy. The study encompassing 1.85 million orders from a Swedish e-commerce organization shows that even though order frequency increases, financial benefits including order handling is decreased with a lenient return policy as shown in table 2.1 (Ibid.). The variables in the table indicate the following:

- **Purchase habits** - Binary variable determining if customer is returning to the online store during period when study was conducted.
- **Return habits** - Binary variable determining if customer has returned a product during the study period.
- **Free returns** - Binary variable determining if returns are free of charge.
- **Mean** - Mean net contribution in SEK.
- **Standard deviation (SD)** - The standard deviation of data sample in SEK.
- **No. of Orders (thousands)** - Number of orders for sample size.

To exemplify, the first row in table 2.1 says that customer belonging to this group did not return to the online store or returned any products during the study period. Customers in this group were not offered free returns. The mean net contribution of a single order was 429 SEK, as shown in the fourth column. The fifth column shows a standard deviation of 443 SEK. The total number of orders for this particular data sample was 333.000.

Average contribution per order (SEK)					
Purchase habits	Return habits	Free returns	Mean	SD	No. of Orders (thousands)
0	0	0	429	443	333
		1	387	398	139
		Total	417	431	472
	1	0	169	327	75
		1	126	246	104
		Total	144	284	180
	Total	0	381	436	408
		1	275	365	244
		Total	342	414	652
1	0	0	409	334	177
		1	342	322	39
		Total	397	333	217
	1	0	304	259	212
		1	207	221	105
		Total	272	251	317
	Total	0	352	300	389
		1	244	260	144
		Total	323	294	533
Total	0	0	423	409	511
		1	378	383	179
		Total	411	403	689
	1	0	269	285	287
		1	167	237	209
		Total	226	270	496
	Total	0	367	376	798
		1	264	330	387
		Total	333	365	1185

Table 2.1: The table shows differences in contribution between customers segmented by purchasing characteristics (Hjort and Lantz, 2016).

Table 2.1 demonstrates that attracting customers with free returns increases sales revenue but also increases costs, and thus impacts profitability. Moreover, since free returns tend to incite higher rates of return, the sustainability aspect is also weakened (Oghazi et al., 2018). To conclude, Hjort et al. (2013) suggest that firms should use data to a larger extent and that customers could be segmented to improve profitability. The reason behind this is revealed by the table 2.1, which shows that customers using the free return opportunity and returning customers have a lower contribution in comparison to repeat customers.

As a result of product lenient return policies, the online fashion industry experiences high return frequencies (Arthur, 2017). According to Sophie Glover, head of technical services at Asos, their customers treat the free return service as a changing room experience (Ibid.). According to an industry report by Mulpuru (2017), three indicators highlight the issue of returns in the fashion industry. 48% of all respondents have returned an order past 12 months. Additionally, 49% actively look for return policies, where free return shipment is a qualifier for making a purchase. Finally, 40% of the respondents state that they buy multiple items, which supports Sophie Glover's statement (Arthur, 2017). This negative impacting trend of frequent returns is expected to continue (Dennis, 2018). Altogether, this data indicates that firms having a e-commerce channel are experiencing a severe situation, with strong growth but with increasing return frequencies and handling costs (Ibid.). As a result, it has a critical impact on margins and has put them in position with suffering profitability (Oghazi et al., 2018).

An example of efforts made by online retailers to combat the problem of increasing return frequencies is implementing more sophisticated solutions for retrieving customer measurements. The rationale behind this is to mitigate the risk of customers being unsatisfied with the fit of the apparel they receive (Ratcliff, 2014). By implementing solutions like this, Asos managed to reduce the return rate by 50% (Ibid.). These tools enable the user to provide certain measurement and thereby decrease the size uncertainty, which account for up to 65% of reasons behind all returns (Ratcliff, 2014).

2.4 From Fast Fashion to Slow Fashion

Contrary to trends of increasing sustainability, consumers in fast fashion tend to neglect the fact that this sector of fashion leaves a significant carbon footprint (Turker and Altuntas, 2014). The concept of fast fashion is based on short life cycles and is driven by a low price and at a comparably low quality. Here, sustainability aspects seem to be overlooked (Ibid.).

Turker and Altuntas (2014) fragment fast fashion strategy into the following operational activities: rapid prototyping, batches of small quantities, large product variety and state of the art supply chain. To realize the dimensions of speed and flexibility effectively, quality control is of prime importance (Tokatli, 2008). The fast fashion player Zara has managed this by having its own design department and limiting their outsourcing of apparel production to only 13%, often taking place in Turkey and China (Tokatli, 2008). Interestingly, there are significant operational differences in terms of cost and lead time when these two countries are compared. Tokatli (2008) presents an example regarding large volume production where Chinese producers generally offer a lower price per item but have up to three weeks delivery time, which can be compared to Turkey's five days in this case. What also increases the speed is that garments are often retail store prepared, meaning that they can be brought directly to the shelf after delivery since the apparel is already hanging on hangers and price tags are attached (Ibid.).

Aligned with the fast fashion theory presented by Turker and Altuntas (2014), Čiarnienė and Vienažindienė (2014) have defined the fast fashion concept with some key characteristics, visualized below in figure 2.7. Each dimension in figure 2.7 facilitates the overarching objective to increase responsiveness to the market (Čiarnienė and Vienažindienė, 2014). Elimination of stages means that processes such as product development and quality control are eliminated from the supply chain. Furthermore, the interest for seasonal apparel where the customer can express themselves through customized clothing is increasing (Ibid.). As a result, the market requires increased product variety, where shorter production runs is seen as key and large batch sizes are seen as less important (Ibid.). Therefore, production location for the seasonal category has shifted from the Far East to Turkey to improve time to market (Ibid.). The latter is considered an established fashion manufacturing country that offers faster distribution thanks to the smaller distance to end consumers, but at a higher production cost compared to the Far East (Ibid.).

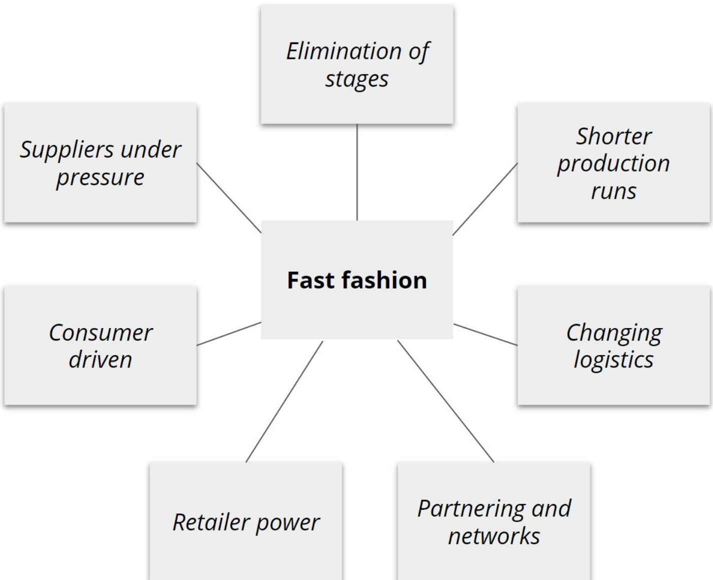

Figure 2.7: According to Čiarnienė and Vienažindienė (2014) fast fashion has seven key characteristics illustrated above.

The fast fashion concept has adopted fast agile elements such as the importance of strong partnerships and cooperation where information can be shared to enable flexibility efficiently (Čiarnienė and Vienažindienė, 2014). Time can be saved when this is managed efficiently, which can result in a competitive advantage. According to Čiarnienė and Vienažindienė (2014), the fast fashion concept is demand driven. Thus, players in the fashion value chain rely on retailers' information that control supply (Ibid.). As previously mentioned, the market interest for product variety has increased. Therefore, suppliers experience increased pressure to fit in a growing supplier portfolio (Ibid.).

In parallel with customers' increasing environmental awareness, a new manner of producing fashion has emerged called slow fashion (Fletcher, 2010). What characterizes this concept is a shifted focus from stimulating over-consumption to instead prioritizing social and environmental aspects (Cataldi et al., 2010). The idea of slow fashion is not only to make more durable products with traditional manufacturing methods but also to supply the market with season-less collections (Ibid.). Altogether, these factors contribute to an extended product life cycle and should contribute with a sense of prioritizing aspects of ethics and resourcefulness (Fletcher, 2010). Moreover, since the slow fashion concepts allow longer lead times, Cataldi et al. (2010) suggests that the consumer should take part of the design process to satisfy identity- and creativity needs.

However, Fletcher (2010) argues that the slow fashion movement will not replace the fast fashion industry. Fletcher (2010) states that these two concepts are not opposites to each other, but rather different industry approaches with different characteristics. To clarify, business models, means and processes distinguish between these two concepts. Lastly, Fletcher (2010) argues that the term "slow fashion" is utilized to market products that happen to be more sustainable compared to fast fashion apparel for some reason.

2.5 Financial Impact

Due to market uncertainty, it could be preferable for fashion producers to move from producing to inventory based on forecasts. Instead, their decisions should be based on real time market information to deal with market volatility effectively and thereby deploy a pull strategy (Ungvarsky, 2017). However, this implies that the production is heavily dependent on market demand. The importance of supplying the market effectively can be clarified by the table 2.2, which shows where in the value chain profit is impacted (Christopher et al., 2004). It can be seen that the biggest revenue losses occur in retail where they amount to 16.4%. The biggest factor is forced markdowns, amounting to over 14% decrease of total revenue (Christopher et al., 2004). Forced markdowns only refer to when fashion goods must be moved from store because of the season ending or new collections entering the store shelves (Ibid.). This means that special sales are excluded here (Ibid.). In total, this profitability impact have a total impact of 25% as seen in table 2.2 (Christopher et al., 2004). Instead of having a push market supply, Čiarnienė and Vienažindienė (2014) suggest for retailers to implement a pull market supply to provide the market with appropriate volumes of requested products.

Profitability impact across fashion industry value chain (% of revenue)				
Type	Fibre & textile	Apparel	Retail	Total
Forced markdowns	0.6	4.0	10.0	14.6
Stock-outs	0.1	0.4	3.5	4.0
Inventory 15% carrying cost	1.0	2.5	2.9	6.4
Total	1.7	6.9	16.4	25.0

Table 2.2: The table exemplifies profitability impact in fashion industry (Christopher et al., 2004).

2.6 Introduction Conclusion

Until now, multiple challenges in the fashion industry have been introduced. Some factors concerning sustainability are product life cycle, returns and customer preferences. To address the need for custom-made, price levels must meet customer expectations. Here, scale is an interrelated element where automation is anticipated as an enabler. In parallel with this shift, the prerequisites of production capabilities are improving as the technology develops, which makes it more interesting than ever to investigate in challenges and opportunities of industrial custom-made fashion production. More precisely, abandoning forecasts in favour of implementing demand driven production could be a solution for economically and environmentally sustainable fashion. This could avoid over-production and forced markdowns.

Table 2.3 has been compiled in an attempt to summarize key areas presented in this introductory chapter, and to give an idea of how the areas relate to each other. These areas are assumed to be of interest to understand when attempting to explore the possibilities for industrialization of custom-made clothing. Therefore, several subsequent steps in this project work are carried out with the intention to dig deeper into these areas and concepts.

Topic Summary		
Area	**Topic**	**(Clarification)**
Challenges		
	Lacking market supply strategy	e.g. overproduction, return policy
	Product uncertainty	
	Changing customer preferences	
	Increasing sustainability importance	
Implications		
	Low product forecast ability	
	Decreasing profitability	
	Short product life cycles	
	Among most polluting industries	
	Forced markdowns	
	Inventory capital	also related to forced markdowns
	High return frequency in e-commerce	
Enablers & Requirements		
	Cost efficiency	e.g. automation
	Omni-strategy	
	Partnerships	vertical- & horizontal integration
	Technology	e.g. AR/VR & automation
	Custom-made production	e.g. personalization
	On-demand manufacturing	
	Shorter lead time	e.g. nearshoring

Table 2.3: The table presents a topic overview and their relation to each other.

3
Purpose

This chapter introduces the focus and frames of the project. This includes three areas: a purpose statement in section 3.1 that elucidates the aim of the thesis, research questions in section 3.2 that specify the focus and delimitations in section 3.3, which sets frames of the project.

3.1 Purpose Statement

The purpose is to analyze challenges and opportunities in industrializing manufacturing of custom-made apparel.

3.2 Research Questions

The research questions were derived from the purpose statement. To fulfill the purpose a set of three research questions was formulated:

1. What can be operational challenges in industrial custom-made apparel?
2. What can be reasons for operational challenges in industrial custom-made apparel?
3. What opportunities could emerge for stakeholders of the custom-made apparel value chain?

3.3 Delimitations

The focus of this thesis is operational and technological aspects of industrializing custom-made apparel. This includes aspects that are directly connected to the creation of such garments, such as receiving customer measurements, information transfer within the value chain, manufacturing technology and logistics. However, other aspects that may have a considerable effect on the adoption of such fashion, but are outside the influence of the individual firm, are excluded from the scope of the thesis. In section 4.3, several models for analysis are introduced. From the perspective of figure 4.2, the key focus of this thesis are operational operations and operational technology, while operational marketing and operational finance are excluded. Of the eight steps in the fashion value chain presented in figure 2.1, the project focuses on *Design & development*, *Manufacturing* and *Retail*.

4
Theory

This chapter presents key areas that will form a theoretical foundation for the thesis. The first two sections present two commonly used operational ideologies, lean and agile, briefly discussing underlying aspects dictating companies' approach to their operations. The third section is Operations Strategy (4.3), which presents some generic frameworks for positioning and managing operations successfully. Furthermore, this section includes Supply Chain Management (4.3.1), which is critical to consider when evaluating the attractiveness of custom-made apparel. This is followed by another subsection called Process Technology Strategy (4.3.2), which presents how technology can be used to enhance operations. The fourth section is Industry 4.0 (4.4) and focuses on how connectivity can improve operations. The fifth section is Augmented Reality (4.5) and deals with its technology namesake, which is anticipated to gain recognition and acceptance within the fashion industry. Lastly, a Theory Summary (4.6) concludes the chapter to provide a structured theory consolidation for the analysis.

4.1 Lean Manufacturing

Ungvarsky (2017) defines lean as "a business system that strives for increased value and productivity by cutting waste of all sorts". Ungvarsky (2017) argues that companies that apply lean thinking "are able to get more work done faster and with fewer workers while still maintaining or improving quality, through eliminating wasted effort, time and resources." Pettersen (2009) on the other hand claims that the concept of lean is hard to define precisely, given that for every author discussing the concept, different aspects and ideas of it are emphasized. Pettersen (2009) attempts to map out a consensus on the definition by comparing and finding overlapping elements from various sources. Characteristics found to be discussed as comprised by the term lean production by every one of the authors analyzed were just in time practices, resource reduction, improvement strategies, defects control, standardization and scientific management (Ibid.).

Much of the lean movement is based on ideas from the highly efficient manufacturing and culture of Japanese car manufacturer Toyota (Liker, 2004). After World War II, while American manufacturers could rely on economies of scale to a very high degree, Toyota's market was smaller and needed to have higher flexibility, and thus relentlessly tried to eliminate wasted time and material from every step of their process (Ibid.). According to Liker (2004), being a lean manufacturer requires "a focus on making the product flow through value-adding processes without interruption (one-piece flow), a pull system that cascades back from customer demand by repleneshing only what the next operation takes away at short intervals, and a culture in which everyone is striving continuously to improve".

A study by Vilkas et al. (2015) shows companies adopting lean principles for a number of reasons, of which several important ones are presented in table 4.1. In the study, companies were asked to which extent the different factors affected their decision to adapt lean methodologies, ranked from 1 (negative influence) to 5 (positive influence) (Vilkas et al., 2015). Vilkas et al. (2015) concluded that the dominating motives behind lean adoption indicate an aspiration for increased efficiency, delivery speed, decreased costs and defects in companies' operations. However, Vilkas et al. (2015) also underscore that further effort is required to become lean and agile (explained further in the following section) simultaneously, and thus achieve capabilities of introducing new products fast and mass-customize cost-effectively.

Factor	**Mean**
Efficiency	4.15
Problem solving	4.15
Housekeeping level	4.11
Improvement of organization	4.10
Identification and prevention of problems	4.08
Satisfaction of customers	4.08
Profit	4.03
Commitment of employees to seek objectives of organization	4.03
Process management/understanding of process of organization	4.00
Competence of employees	4.00
Competitive position	3.97
Level of non-value adding activities	3.95
Quality of products/services	3.92
Fulfilling production/service plans	3.91
Involvement of employees into continuous improvement	3.89

Table 4.1: Factors influencing adoption of lean methodologies among companies surveyed, ranked by mean influence on a scale from 1 (negative influence) to 5 (positive influence) (Vilkas et al., 2015).

4.2 Agile Development

The agile working methodology originates from the software development industry and aims to facilitate flexibility, increase collaboration and deliver final product within a short time frame (Slack and Lewis, 2011). In brief, this means that organizations should be able to frequently change and deliver quickly (Cohen et al., 2003). The ideology came up as a result of the ongoing shifting business landscape, where it is more important than ever to adapt (Ibid.). It was concluded that the traditional way of developing software was too slow, and as a result new methods were devised. Agile methods share the same approach characteristics and are not seldom iterative (Ibid.). These methods rest on the Agile Manifesto, which was defined in 2001. It summarizes the viewpoint of agile methods and is stated below in four bullet points (Cohen et al., 2003; Georgsson, 2010):

- Individuals and interaction over process and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

Cohen et al. (2003) highlights the importance of customer focus over spending time on documentation and strictly following a plan. Nevertheless, some degree of planning is needed; the idea is to react rather than following a pre-set path (Ibid.).

According to Čiarnienė and Vienažindienė (2014), the agile supply chain is defined in four key aspects, presented in table 4.2. The first one is *market sensitivity*, which explains to what extent an organization can react to market demand (Ibid.). The second characteristic is *virtual*, highlighting the fact that an agile organization is strongly dependent on information flow, rather than physical products (Ibid.). This phenomenon is called a virtual supply chain, which is becoming increasingly important due to demand volatility (Christopher and Towill, 2000). The accessibility of information lets fashion players be more responsive to fluctuations in demand (Ibid.). Thirdly, *process integration* is seen as key to efficient cooperation (Čiarnienė and Vienažindienė, 2014). The integration happens between suppliers and buyers, who collaborate in different activities across the value chain (Ibid.). The last one is *network-based*, which highlights the importance of being linked to partners as a network where the aim is to form a competitive supply chain rather than acting as an entity alone (Ibid.).

Characteristics of an agile supply chain	
Characteristic	Clarification
Market sensitive	Ability of organizations to react on market fluctuations.
Virtual	Access to information to facilitate operations.
Process integration	Highlights the importance to collaborate across supply chain.
Network based	Highlights the importance of being connected between players.

Table 4.2: The table summarizes characteristics of an agile supply chain, as presented by Čiarnienė and Vienažindienė (2014).

If an agile mindset is adopted among players in the fashion value chain, it can result in improved performance across the value chain as illustrated in figure 4.1 (Čiarnienė and Vienažindienė, 2014). Time-to-markets emphasize the importance of being able to supply the market in time (Ibid.). This is key since the fashion market demand is shifting rapidly, as described in chapter 2 (Ibid.). Čiarnienė and Vienažindienė (2014) highlights the importance of responding quickly, giving two reasons for this. Firstly, being late implies missed revenue (Ibid.). Secondly, when a product finally is launched, it might be too late because there is no need for the product or service anymore for instance (Ibid.). The second time dimension is time-to-serve, which underlines the importance of providing customer satisfaction in time (Ibid.). Lastly, time-to-react highlights the aim to supply customer requirements at any time and place (Ibid.). This means operations must be flexible not only in providing a variety of product characteristics, but also fluctuating quantities (Ibid.).

Inside the circle of time dimensions, three different activities are presented (time in supplying, time in producing, and time in distributing). Altogether, by efficiently managing these activities, the three time dimensions can be met efficiently (Čiarnienė and Vienažindienė, 2014). To enable quick response, Čiarnienė and Vienažindienė (2014) presents two operational areas including subareas, agile manufacture and agile logistics. As illustrated in figure 4.1, this does not only have a positive impact on suppliers and manufacturers, but also retailers. Thus, by achieving an improved supply chain, it also has the potential benefit end-customers (Ibid.).

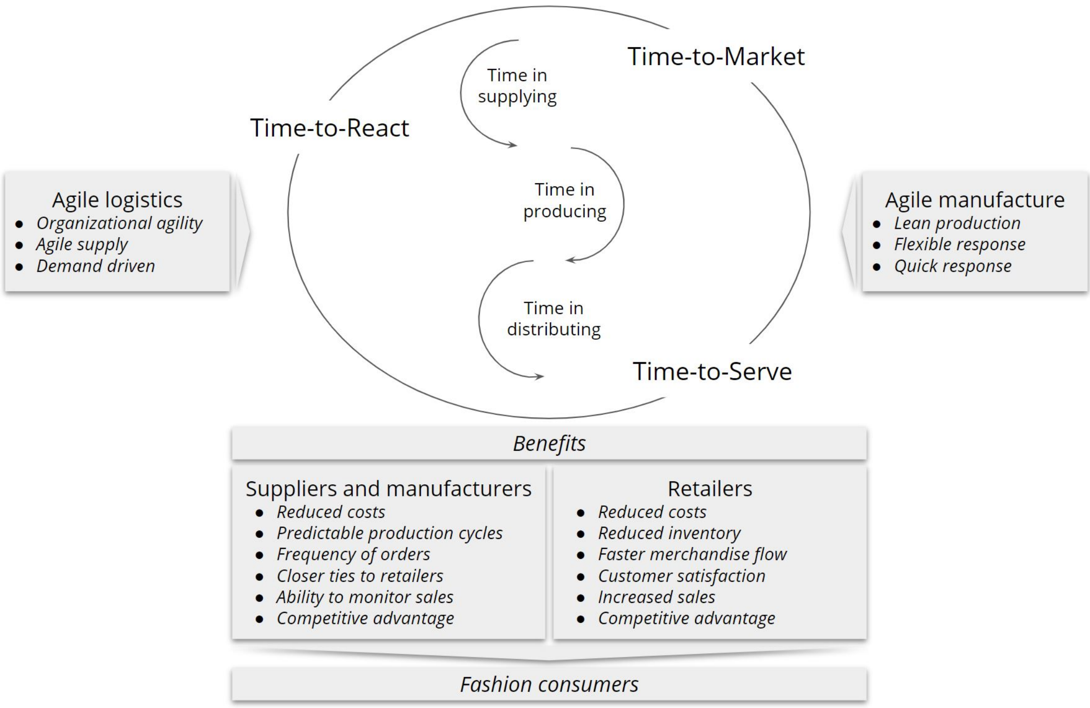

Figure 4.1: Čiarnienė and Vienažindienė (2014) has modelled what an agile supply chain management in the fashion industry can achieve.

4.3 Operations Strategy

Slack and Lewis (2011) distinguish between two different models when governing a business: the business model and the operating model. These two models are closely interlinked for the overall business development (Ibid.). The objective for the business model is to set the overall aim and objectives for the operating model. Furthermore, the operating model replies by defining how objectives of the business model will be met (Slack and Lewis, 2011).

Slack and Lewis (2011) divide functional strategy into four subareas shown in figure 4.2. Each one of these has specific focus areas with an overall aim to improve the business (Ibid.). As shown in figure 4.2, operations strategy deals with operational operations. This includes planning short-term business activities of operational areas for production and logistics as an example (Ibid.). Operations excellence is particularly important for strategic success, since it has the ability to influence four critical areas that determines success of an organization (Ibid.). More specifically, it has the ability to influence the cost side. By working efficiently, organizations can increase output with less resources. Secondly, having the right operations strategy can increase revenue (Ibid.). For instance, if an organization manages to generate a high degree of customer excitement, customers are willing to pay more and/or order bigger quantities (Ibid.). Thirdly, dealing efficiently with operational risk implies better operational adaption to market fluctuations (Ibid.). Lastly, operations strategy also has the ability to influence invested capital (Ibid.).

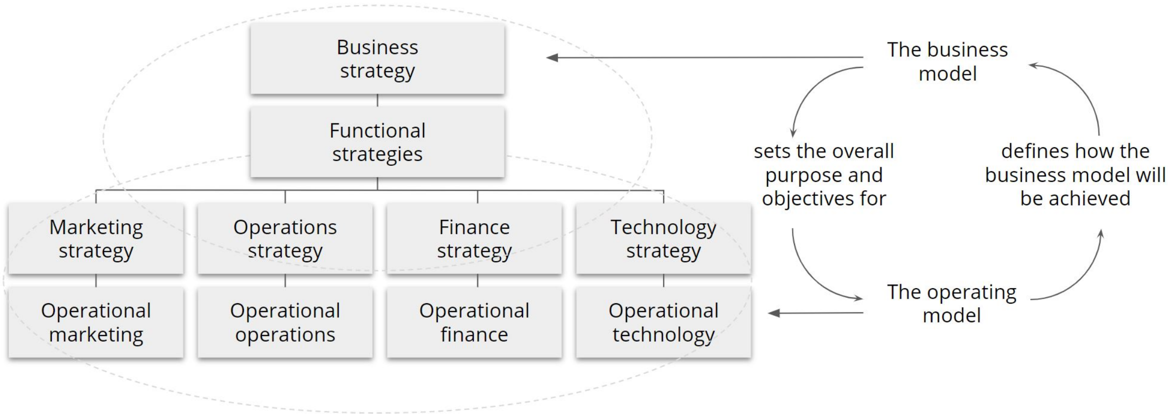

Figure 4.2: The figure presents an overview of strategy areas and how they are linked together (Slack and Lewis, 2011).

More specifically, operations strategy elaborates on four different perspectives, presented in figure 4.3 (Slack and Lewis, 2011). The top-down perspective focuses on how the operations strategy should interpret the high-level strategy (Ibid.). Antithetically to the top-down perspective, the bottom-up perspective aims to collect insights from the daily activities and bring them back to a strategy level (Ibid.).

The horizontal perspectives visualized in figure 4.3 aims to make a fit between what capabilities an organization possesses and what the market requires (Slack and Lewis, 2011). Also, the perspective to the left, operations resources, aims to build appropriate capabilities to maintain long term competitiveness (Ibid.). Altogether, this framework emphasizes critical strategic areas to supports organizations in tailoring the overall operations strategy (Ibid.). Since the vertical dimensions generally are firm-specific, the focus of the project will be to discuss the horizontal dimensions to keep insights at an industry level.

Figure 4.3: The figure shows an overview of the four different perspectives that are included in operation strategy according to Slack and Lewis (2011).

To summarize the operations strategy section, Slack and Lewis (2011) state that neither agile nor lean manufacturing should be considered substitutes for strategy. These concepts are methodologies that can support organizations in achieving operational advantages (Hayes and Pisano, 1994). Thus, organizations must decide what operational capabilities they want to build to reach operational excellence (Ibid.). It can further be explained by figure 4.4, which clarifies how operational objectives of organizations can be categorized (Slack and Lewis, 2011). The first one is quality and highlights the importance of providing a product according to the customer's expectations (Ibid.). Speed indicates an aim to supply the customer as fast as possible (Ibid.). The third objective underlines the importance of being just in time with product supply (Ibid.). Fourthly, flexibility implies an aim to be able to change in order to supply the market with a wide range and in mixed volumes. Lastly, the cost aspect aims to be efficient (Ibid.).

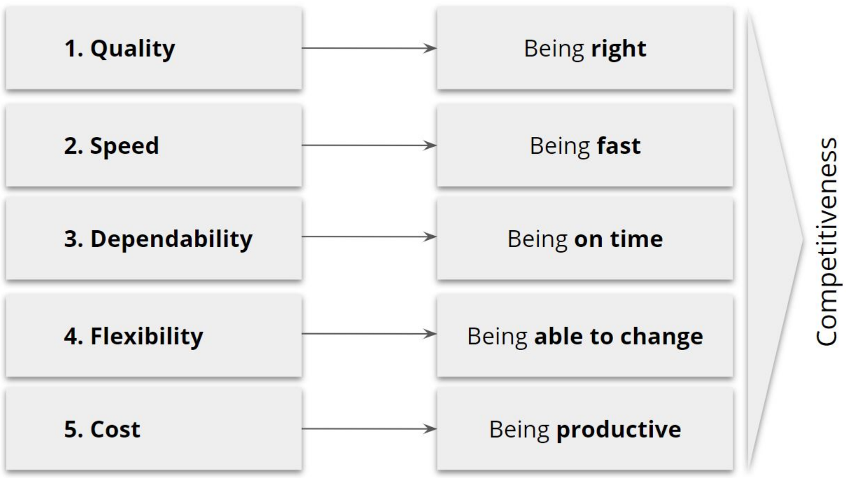

Figure 4.4: The figure visualizes what dimensions of objectives organizations have to build competitiveness (Slack and Lewis, 2011).

4.3.1 Supply Chain Management

Supply management can be defined as "an integrative philosophy to manage the total flow of a distribution channel from the supplier to the end ultimate user" (Ellram and Cooper, 1990). According to Lambert et al. (1998), the interest from organizations for the supply chain has risen and focus has now shifted from being competitive as an entity to instead being a part of a competitive supply chain. Ellram and Cooper (1990) describe this supply chain phenomena as something in between full vertical integration, where a single organization performs the entire value chain, and channel isolation, where each channel performs specific activities as independent firms (Ibid.).

According to Cooper and Ellram (1993), there are two key advantages of having an efficient supply chain. Firstly, it allows organizations to reduce inventory across their value chain (Ibid.). Through closer collaboration with up- and downstream channel members, inventory can be better planned (Ibid.). As a result, turnover fluctuations can decrease (Ibid.). Secondly, there is an opportunity to increase customer service in terms of appropriate market supply (Ibid.). It can be explained by eliminating redundant inventory. By doing this, the safety stock and service level for customers can be appropriately set (Ibid.). Altogether, this brings competitive advantage, where leaner organizations possess improved cost control and increase overall profitability (Ibid.).

Christopher and Towill (2000) highlight the importance of having efficient supply chains to cope low predictability and high variety. In difference to a lean perspective, where low variety and high predictability are key features, being agile supports the opposite performance as seen in figure 4.5 (Ibid.). This means that an agile approach could be more suitable for today's business climate where coping variety is key (Ibid.).

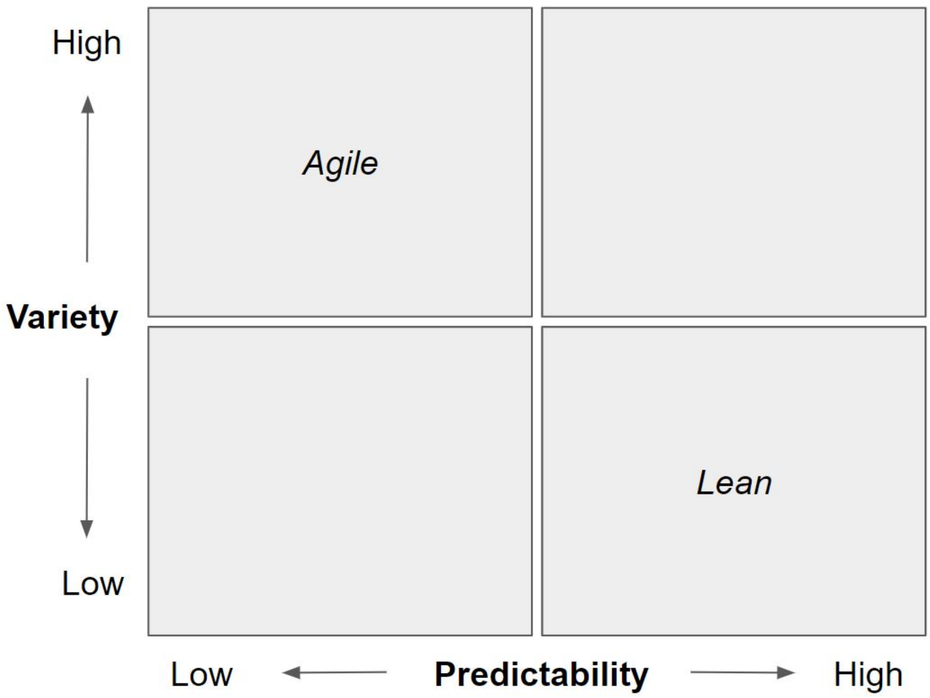

Figure 4.5: The figure illustrates key differences between lean and agile organizations (Christopher, 2000).

Mason-Jones et al. (2000) summarize a comparison between these two business approaches and prioritize key features of these. To determine how to prioritize between these two concepts, one must consider what an organization wants to achieve (Mason-Jones et al., 2000). As shown in 4.6, the two approaches differ from one another not only in terms of priorities, but also regarding their objectives. Presented in order of importance, quality, cost and lead time are market qualifiers for an agile market supply (Mason-Jones et al., 2000). Furthermore, the service level factor is considered to be a market winner (Ibid.). The lean approach has slightly different characteristics, as shown in 4.6. Quality is still considered to be the most important market qualifying factor, but in this case cost gives up the second place for lead time (Ibid.). As market winner the cost factor is considered to be the most important for lean (Ibid.).

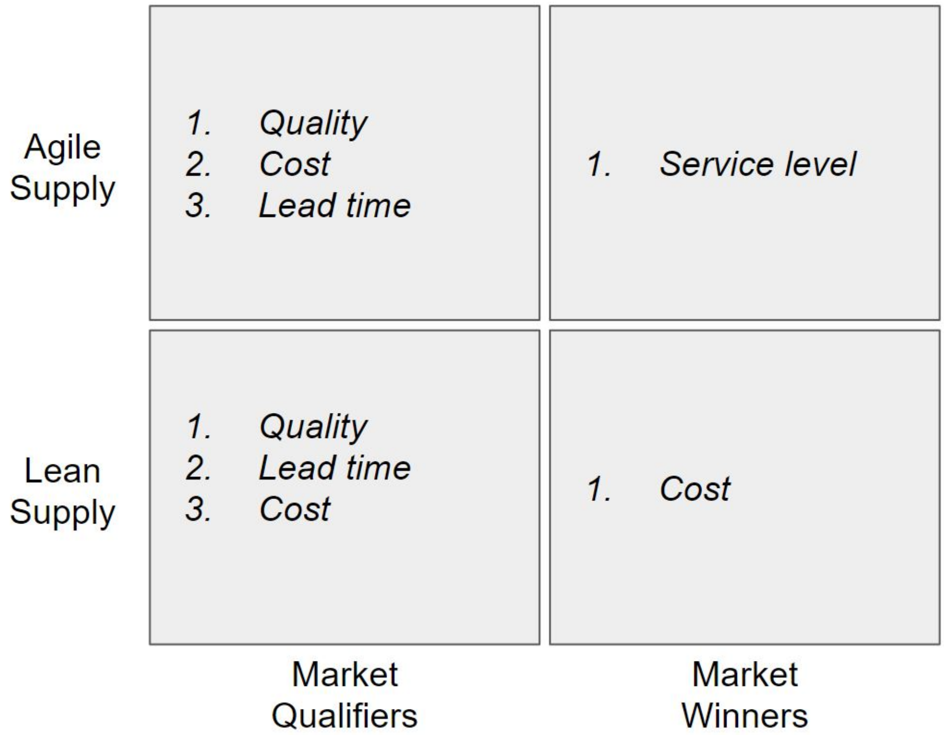

Figure 4.6: The figure compares top attributes between lean and agile approaches (Mason-Jones et al., 2000).

Interestingly, Naylor et al. (1999) presents a more inclusive view of lean and agile business approaches. Naylor et al. (1999) criticize the commonly accepted view that lean and agile are two distinct principles. Instead, they argue that these two concepts should be combined and deployed to the overall supply chain strategy (Ibid.). This view further supported by the operations theory applied to a fashion context stated by Čiarnienė and Vienažindienė (2014).

There is an inherent trade-off between offering product variety and standardizing production to achieve cost efficiency (Wheelwright and Clark, 1992). However, Daaboul et al. (2015) explain how this can be mitigated through mass customization, where firms are able to maintain both production flexibility and cost efficiency simultaneously (Ibid.). According to Van Donk (2001), manufacturing should be divided into two categories: made-to-stock and made-to-order. Which category a certain product belongs to is determined by whether it is customer specific or not (Ibid.). However, this is turns out to be not that obvious when considering the CODP model where products turn customer specific at a certain time (Ibid.). The transition point between generic and customer specific is called CODP (customer order decoupling point), illustrated in figure 4.7, and is a fundamental concept when considering mass customization (Ibid.). Driven by demand means utilizing a pull strategy where the product is being customer specific earlier compared to forecast driven products.

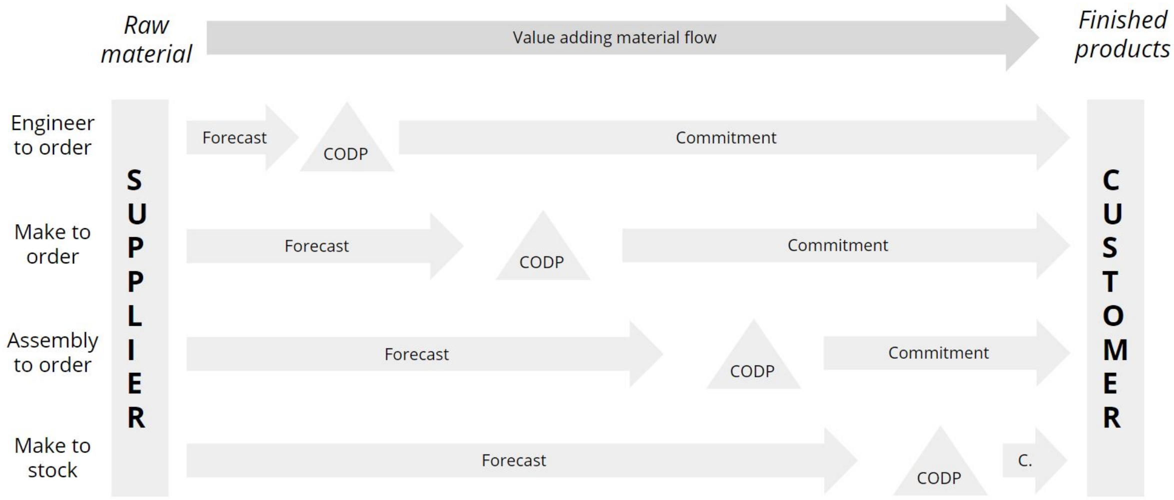

Figure 4.7: Where the customer order decoupling point takes place in the value chain is a critical factor to consider, according to Christopher (2000).

To put the CODP model into a fashion context, an entirely new product sample where engineering activities are highly specific for the garment creation would be at the highest level of the model, *engineer to order*. A tailor made suit on the other hand would typically be placed at the second highest level, *make to order*. It will be strictly related to the end-customer's preferences early in the process. Something below this could be a shirt with customization options. Here, initials and buttons could be changed at a later stage which means that the CODP is postponed. However, still some modifications are needed and thus, the product will be customer specific at some point, meaning it can be categorized as *assembled to order*. A product located at lowest level would typically be a standard shirt without any customization options, referred to as *made to stock*. This process is usually driven by forecasts as of today. Notably, Van Donk (2001) emphasizes the importance of designing products in a way that enables moving the CODP as close to the customer as possible to manage stock efficiently.

Wheelwright and Clark (1992) suggest two different strategies to postpone the CODP, i.e. achieve mass customization without compromising standardization and cost efficiency. The first strategy is modularization, which suggests that products should be built by assembling multiple components that can be used for different products. As an example, a stationary computer comprise different modules, where keyboard, computer and screen can be defined as modules. As a result, products can be customized to some extent while firms can preserve standardized production (Ibid.). The second strategy is called platform strategy and is defined as a collection of assets shared by a set of products (Robertson and Ulrich, 1998). These two strategies enable firms to deal with an increased product design uncertainty in an efficient way (Koufteros et al., 2002).

4.3.2 Process Technology Strategy

Slack and Lewis (2011) present four decision areas that are crucial for achieving market competitiveness: capacity, supply network, development & organization and process technology strategy. The latter refers to the technology that adds value to the creation of any operations service. According to Slack and Lewis (2011), this decision area includes issues such as:

- Characterizing process technologies for the operation
- Understanding overarching characteristics of process technologies over time
- The performance potential of new technology
- Assessing process technology
- How process technology impacts performance objectives

Process technology is further fragmented into three different areas that set the operational focus as seen in figure 4.8 (Slack and Lewis, 2011). *Scale* is the first dimension, which highlights the issue of volume (Ibid.). This includes whether the operation should focus on few, large units of technology, or many small ones. The second area is *automation*, which highlights the level of severity possessed by a process (Ibid.). Lastly, the third area *coupling* aims at technology integration (Ibid.). A high coupling level means that the technology is well integrated. When there is no integration, technology is separated and operational activities require additional support between process stages (Ibid.).

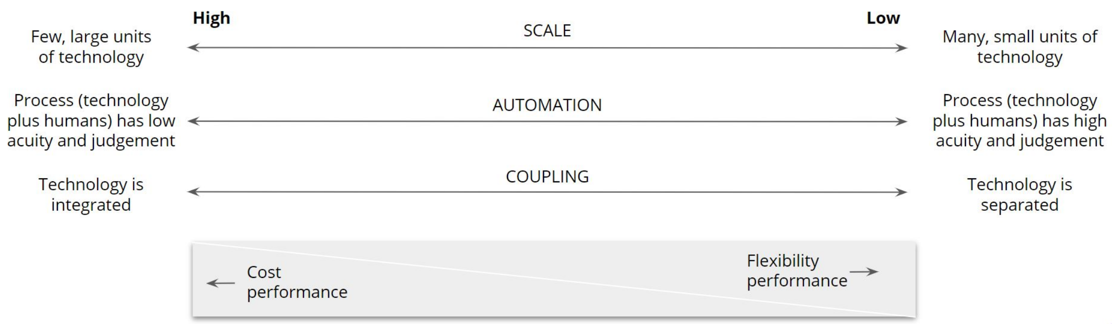

Figure 4.8: The figure explains three dimensions of process technology defined by Slack and Lewis (2011).

Altogether, these three process technology areas are closely connected, and determine cost or flexibility performance as seen in figure 4.8. Slack and Lewis (2011) define this cost flexibility as an inherent trade-off where organizations must decide what characteristics their operations want to achieve. However, as information technology (IT) develops, organizations are able to push their operations characteristics off the diagonal as seen in 4.9 (Ibid.). Organizations are able to achieve both flexibility and cost performance by succeeding in integrating their IT strategy as a part of their overall operations strategy (Ibid.).

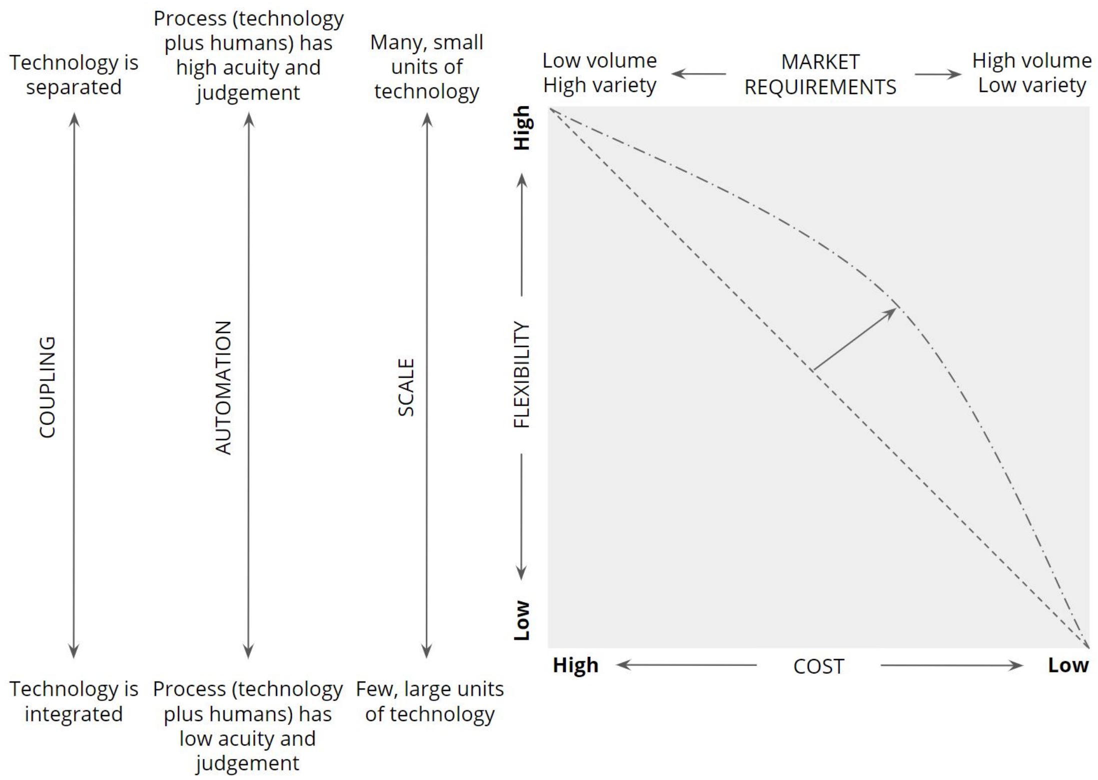

Figure 4.9: The figure visualizes where organizations position their process technology to achieve certain operational capabilities (Slack and Lewis, 2011).

Interestingly, Jensen (2003) highlights that it exists a free-rider problem associated with technology adoption. That is, actors are sometimes incited to remain passive and wait for other actors to make a move before deciding on their own course of action regarding the investment in a new technology. Through analyzing the outcome of competitors' moves, information that can be used to minimize one's own uncertainty by acquiring knowledge (Ibid.). In that way, the focal firm has a better understanding of the technology it is considering investing in, which can be crucial (Ibid.). Robinson et al. (2012) argue that the higher the amount of uncertainty in an area, and the higher the expectations, the more likely the situation is to lead to a waiting game (Ibid.). Overcoming a waiting game requires a collective effort to change, which can be challenging in a context of high uncertainty (Ibid.).

On the other hand, Lieberman and Montgomery (1988) presents a variety of advantages of being a first mover. The first benefit is that a first mover can obtain early feedback and acquire market knowledge (Ibid.). The second one is the opportunity to establish a market standard (Ibid.). The third benefit is that first movers have the opportunity to make a strong brand impression and build brand loyalty (Ibid.). This benefit also includes buyer switching cost, which create a barrier for customers to change supplier (Ibid.). The fourth one can be described by the learning curve effect (Spence, 1981). This can be explained that ones a product is developed, it can be optimized and later manufactured to a lower price, which makes it even harder for competitors to launch an competitive product (Lieberman and Montgomery, 1988).

In a process known as technology diversification, firms may diversify their technology base and expand into new areas (Granstrand, 1998). Since a firm with diversified technology also has a greater ability to diversify its business, technology diversification can be used to promote firm growth (Granstrand and Oskarsson, 1994). This sentiment is echoed by Wernerfelt (1984), who argues that the technology base is a very important part of a firm's resources. A firm may broaden its technology base in a number of different ways, with different degrees of integration (Granstrand, 2010). At one end of that spectrum is internal R&D, in which the focal firm develops the technology in a closed, internal environment (Ibid.). At the opposite end, technology scanning is found, during which firms acquire know-how from the external environment, without purchasing it from the source (Ibid.)

4.4 Industry 4.0

Bisio et al. (2018) define industry 4.0 as "a transformation that allows gathering and analyzing data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods and services at reduced costs". The aim is to enable real time interaction among the production resources to create a medium for efficient communication between all connected parties, mainly through the internet of things (Bisio et al., 2018). Rüßmann et al. (2015) describe this "horizontal and vertical system integration" as one of the main technological advances of industry 4.0. They explain that today, there is often scarce integration between customers, suppliers and companies. If this is improved, it can increase flexibility and profitability of smaller batches, as well as improved information transfer throughout the value chain (Rüßmann et al., 2015). This is consented by Tjahjono et al. (2017), who anticipate that companies will be able to create additional value by constantly introducing new products and services in response to market demand, thanks to the swift information flows enabled by new technologies in industry 4.0.

Zhong et al. (2017) emphasize the mass customization that is enabled by increasing flexibility, arguing that companies in the industry 4.0 era have the potential to overcome the challenge of producing high quality, highly individualized goods with short lead-times. Companies can also use new technologies to enhance visibility, traceability and trackability of products through the manufacturing process (Zhong et al., 2017). A case of such activity can be found at Guangdong Chigo Air Conditioning Co., Ltd., who manage shop-floor material levels in real-time through the use of RFID (Ibid.).

Xu et al. (2018) explain that the full potential of industry 4.0 often fails to be realized in today's manufacturing, especially in less developed countries. The main reason is seen as lack of powerful tools needed to enable full implementation of Cyber-Physical Systems, in which physical and software components are highly integrated and seamlessly coordinated (Ibid.). As an example the Chinese government is addressing issues like this through the initiative Made-in-China 2025, which aims to modernize Chinese industry and “transform it from the world’s workshop into a world manufacturing power” by year 2025 (Xu et al., 2018). Kaivo-Oja et al. (2018) note that the increased use of automation, robotics and artificial intelligence will impact companies’ location of production, since demand will shift from low-cost manual workers to skilled labour capable of operating automated production. This could potentially lead to a de-escalation of offshoring and put an emphasis on the geographic transfer of manufacturing to countries closer to the market, a process known as nearshoring (Kaivo-Oja et al., 2018).

An important criteria for the industry 4.0 transition is the collaboration between suppliers, manufacturers and customers aiming to increase the transparency throughout the product life cycle (Tjahjono et al., 2017). If this is managed efficiently, waste can be saved throughout the value chain (Ibid.). Industry 4.0 has spawned new business opportunities in other industries, and Lehmann et al. (2018) anticipate that the fashion industry will be no exception as long as actors within the industry join forces. In order to evaluate the challenges and opportunities brought on by the next generation of technology, it is thus imperative to analyze the supply chain as a whole due to strong interrelations between actors and technology (Tjahjono et al., 2017).

Based case study conducted by Berg et al. (2018), an activity matrix was compiled, shown in figure 4.10. The matrix includes steps in the jeans manufacturing process (horizontally in grey). The process encompasses six steps plus warehouse/intralogistics. Vertically to the left hand side, different technologies are presented. Altogether, the matrix presents the technology maturity and examples for every step in the manufacturing process. The state of the technology maturity is segmented into three different categories: standard today, best practice today and yet not implemented. On the second to last row of the matrix, the complexity of every step is presented, and is related to the technology state of each step. At the bottom of the matrix, example technologies are presented to provide some industry specific solutions.

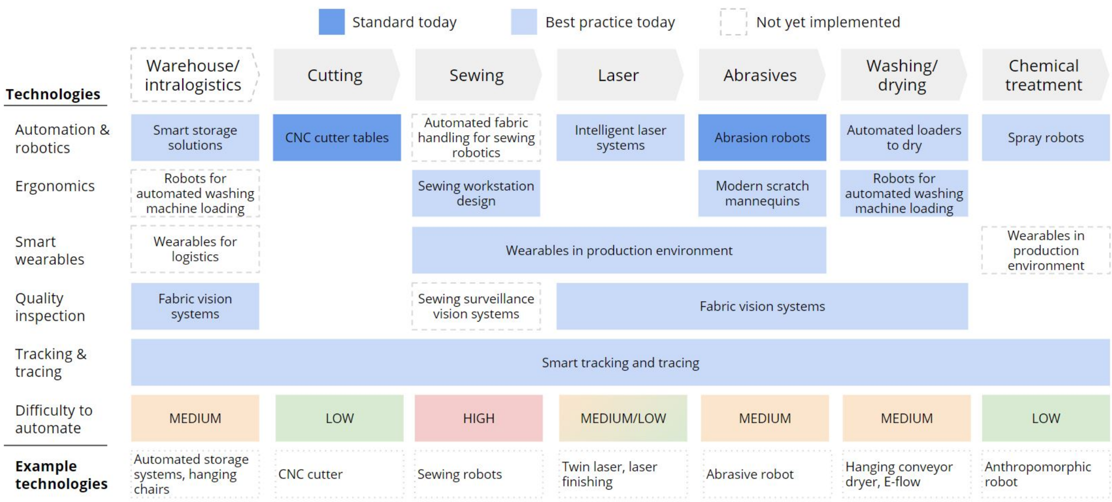

Figure 4.10: The figure visualizes the steps of how a cut-make-trim process of jeans manufacturing and its technology state respectively (Berg et al., 2018).

It can be concluded that the complexity across the manufacturing process varies, and as of today, total automation is not possible (Berg et al., 2018). The issue is primarily driven by the complexity to automate the sewing stage as seen in figure 4.10 (Ibid.). As a result, human involvement is still needed (Ibid.).

If every step in the manufacturing process was modernized by introducing the latest technology, production time could be reduced by 40-70% for a pair of jeans (Berg et al., 2018). This means that the process time could be reduced from 36 minutes to 20 minutes in a conservative scenario, or 11 minutes in an optimistic case, as seen in figure 4.11. The key activity driving this reduction would be the sewing, where technology has the ability to cut labor need by 21% (Ibid.). Even if this technology would be implemented, there would still be a significant need for human involvement in the manufacturing process due to technology limitations (Ibid.).

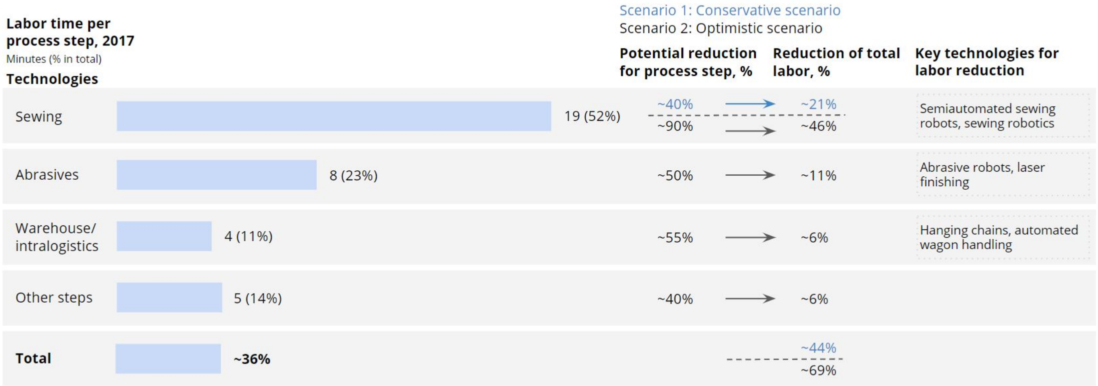

Figure 4.11: The figure visualizes how much time could be saved in the fashion manufacturing process if today's technology was implemented (Berg et al., 2018).

Berg et al. (2018) argue that automation not only has the potential to reduce time and cost in production, but could also contribute with environmental benefits. Figure 4.12 visualizes elements of the value chain that could be improved from an environmental standpoint through automation, nearshoring and closer collaboration between actors. First and foremost, production of renewable & sustainable fibers is critical to provide an alternative to unsustainable materials (Ibid.). According to Berg et al. (2018), this is an element that can be enabled indirectly through closer collaboration in the value chain. The second element is an opportunity in the production of fabrics, where nearshoring could be an enabler (Ibid.). Moreover, automation could also contribute in this regard (Ibid.). Berg et al. (2018) state that automated finishing can improve production efficiency, and as a result, less resources are consumed per item. The third element presents opportunities in production of high-quality, customized garments (Ibid.). For this element, automation is considered to be a key driver (Ibid.). The benefits of this could be increased customer value and pro-longed product life time (Ibid.). Fourthly, Berg et al. (2018) anticipate that there is an opportunity in on-demand distribution and retail sales. This is considered to minimize waste by reducing amount of unsold items, which is a key problem today (Ibid.). This element is considered to be enabled by nearshoring and automation (Ibid.). The fifth element elucidates sustainability opportunities in the end of the value chain (Ibid.). Here, it is recommended to have co-located collection and recycling to mitigate shipping, among other (Ibid.). Lastly, the sixth element highlights the potential to create a circular, zero waste eco-system, which has the potential to positively impact the fashion industry as whole (Ibid.). Waste can be eliminated throughout the whole value chain and old products can be recycled to mitigate environmental impact from fashion industry (Ibid.).

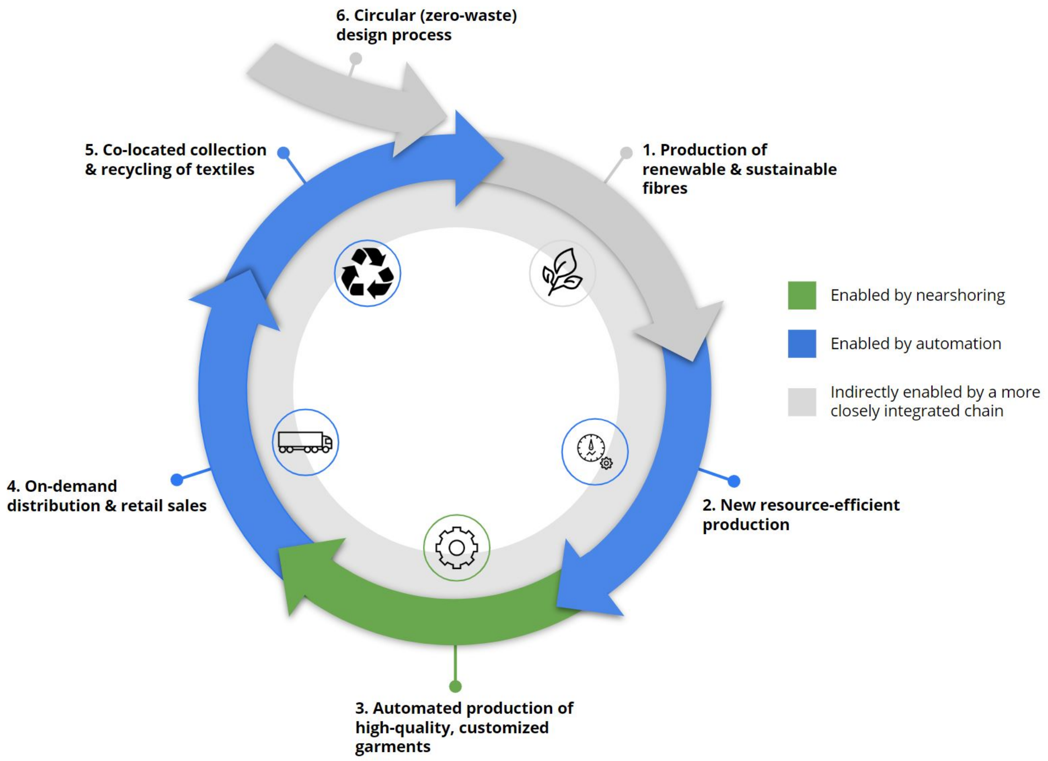

Figure 4.12: The figure visualizes how apparel sustainability can be improved by nearshoring, automation and increased value chain integration (Berg et al., 2018).

4.5 Augmented Reality

Augmented reality (AR) can be described as mix between a virtual and a real nature environment (Kipper and Rampolla, 2012). This concept is realized with technology that enables enriching real life with real time artificial information (Ibid.). Also it performs in a 3D-environment, which makes it applicable to a real life context (Ibid.). The technology has been used over the last decades, where the head-up displays (HUD) is an example from the aerospace industry (Ibid.). It projects information on the wind shield, which is a basic example of AR technology (Ibid.).

In addition to the physical components required to set up an AR experience, Craig (2013) summarizes three key elements that AR technology should include:

- **Interactivity** - The AR experience engages the user in an interactive way which can be enabled in a number of ways with varying degrees of complexity.
- **Real time capability** - The information content provided by the AR technology should be presented in real-time.
- **Relation to context** - The AR experience should be a hybrid between real life and virtual information. This means that the experience is dependent on both the physical and the virtual world.

The concept of AR has experienced dramatic development since the first prototypes were released in 1962 (Kipper and Rampolla, 2012). Back then, AR was a simple concept with limited applicability (Ibid.). However, progression in hardware and software has enabled AR-technology to take on a more advanced role in a variety of industries (Ibid.). This view is further supported by top industry representatives. According to Tim Cook, CEO of Apple, and Greg Jones, Head of AR and VR at Google, the interest for AR technology in the industry is tremendous (Arthur, 2017). According to a survey by Insights (2017), the AR market in the US is expected to have a CAGR of 65% over the next six years, where industrial, automotive and retail segments are expected to grow the most. As a result, hardware suppliers are preparing for this market opportunity (Insights, 2017). The same survey also indicates that customers expect the fashion industry to adopt AR technology in the near future.

Sanna and Manuri (2016) argue that regardless of the rapid growth presented by AR-technology, this growth is limited by content availability since AR is dependent on the environment and the augmented content, as described by Kipper and Rampolla (2012). This implies that the content factor must be addressed by software developers, which limits the diffusion speed and quality of AR applicability. Hence, even though AR technology is anticipated to reach a variety of industries shortly, the development of content will take time since it is related to every specific context (Sanna and Manuri, 2016).

4.6 Theory Summary

Until now, the state of operations in fashion industry and some generic operations frameworks have been presented including two business ideologies: lean and agile. What these frameworks have in common is that they elaborate upon operational decision areas, which are dependent on what an organization want to achieve. To these generic frameworks, technology has turned out to be an important enabler. Thus, insights regarding what technology could be interesting for custom-made apparel manufacturing have been presented. Lastly, Berg et al. (2018) present some insights in operation of the apparel industry, involving factors of both sustainability and manufacturing. Within these areas, challenges remaining before benefits can be reaped have also been presented.

5

Method

This chapter motivates the design of two foundational research activities: research strategy (section 5.2) and data collection (section 5.3). The chapter begins with a section introducing the reader to philosophical concepts that help guide the researcher in tailoring research to a given situation. The subsequent section about research strategy motivates the choice of strategy. Additionally, activities and their sequence in the project are visualized to give the reader an overview of the thesis procedure. The following section on data collection comprises two subsections, which present in further detail how existing literature was studied and how empirical data was collected. Then, section 5.4 discusses the project based on different dimensions on research quality. To conclude the chapter, section 5.5 gives a brief summary of its content.

5.1 Foundation of Research Methodology

The setup of a research study is often dictated consciously or subconsciously to a high degree by the researcher's stance on the philosophical concepts of ontology and epistemology (Easterby-Smith et al., 2015). The former concerns "the nature of reality", while the latter has to do with the theory of knowledge, and how knowledge about the world can be acquired (Ibid.). One's ontological position can be placed on a continuous scale between objectivistic, according to which truth about reality is definitive and beyond our influence, and constructionistic (Bryman and Bell, 2011). The latter argues that truth is relative and dependent on the point of view of the researcher (Ibid.). The first extreme on the epistemological scale, on the other hand, is positivism, where only phenomena confirmed by our senses can be accepted as true (Ibid.). It means that theoretical studies aim simply to generate hypotheses that can then be tested (Ibid.). Antithetical to positivism is interpretivism, according to which not all subjects can be studied in the natural scientific manner that positivism postulates (Ibid.). Instead, researchers in social sciences must consider the distinctiveness between people and the objects that are studied in natural science, to grasp the subjective nature of human behaviour (Ibid.). Easterby-Smith et al. (2015) contends that these philosophical concepts will guide the research design and strategy. According to Wagner et al. (2012), positivism will often imply quantitative research, whereas an interpretivistic position will be accompanied by qualitative methods. Given the nature of the research at hand, which called for qualitative research (as explained below), the authors have attempted to maintain an interpretivistic point of view throughout the project.

5.2 Research Strategy

The research strategy of the project was of qualitative nature. This was preferred since a the purpose was to analyze a new business area, in which case qualitative research is more suitable than quantitative, as argued by Bryman and Bell (2011). This means that the research was of exploratory manner, where opportunities and challenges in new areas are identified (Ibid.).

Bryman and Bell (2011) presents two main research approaches. The first one is called deductive data collection method, which means that data is collected to build a hypothesis (Ibid.). The second one is called inductive research approach, which means data is collected to test a hypothesis (Ibid.). An inductive approach is preferable when data is first collected and then generalized to draw new findings and conclusions (Ibid.). Moreover, an inductive approach facilitates an initial topic overview, which benefits understanding of a certain topic (Ibid.). For this project, a mix of these two research approaches was chosen, namely an iterative research approach. It means that study of theory and collection of data were carried out simultaneously, as visualized in 5.1 (Ibid.). This facilitated the exploratory approach, which ordains building of theories and collection of empirical data simultaneously in order to make progress in uncharted areas (Ibid.).

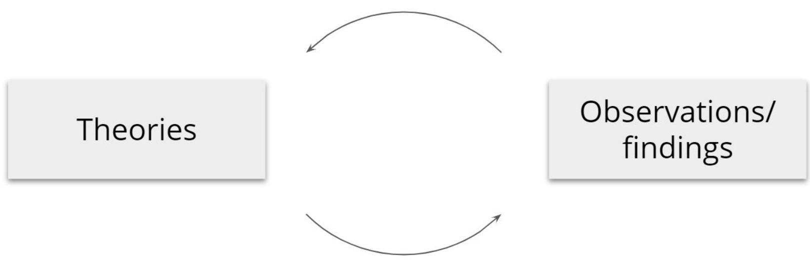

Figure 5.1: The figure illustrates how theory and empirical findings will be used together to progress the project (Bryman and Bell, 2011).

Lastly, the project was conducted as a case study. This research approach is preferable when a single case is intensively investigated (Bryman and Bell, 2011). Hence, this will facilitate an in-depth analysis of the research case and provide a focus structure to the topic (Bryman and Bell, 2011).

To aid the analysis structure some frameworks were utilized. When it comes to the data collection the value chain framework 2.1, defined by Lehmann et al. (2018), was applied. This framework was used to ensure that all critical processes of fashion production were covered. However, as earlier mentioned, primary focus was on step Design & development, Manufacturing and Retail. Insights obtained from the data collection was clustered to identify critical areas and how areas related to each other. This process was followed by applying identified areas to operational frameworks, as stated in the Theory, chapter 4.

Following figure 5.2 outlines how the research was conducted. It includes a time plan of what and when activities were executed, aimed to facilitate coordination of conducted activities.

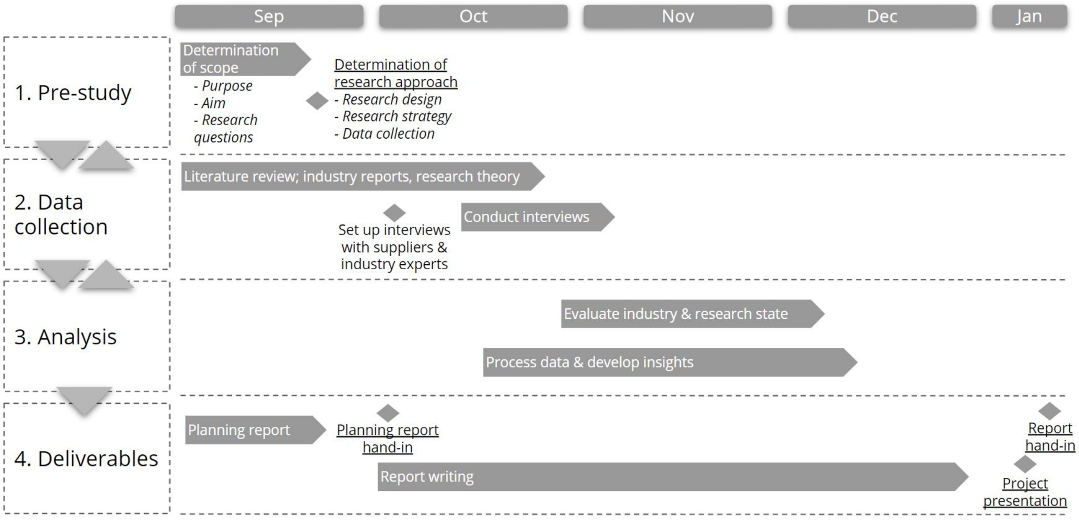

Figure 5.2: The figure presents a time plan including how the research was planned and activities it included.

5.3 Data Collection

The data collection consisted of two different activities, which formed a foundation of data from which the purpose of the thesis could be explored. These two activities were literature review, presented in section 5.3.1, and interviews, presented in section 5.3.2. Using different data sources enabled theory triangulation (Bryman and Bell, 2011). This means that the confidence of theory quality can be improved by comparing data from different data collection methods and thus increase the credibility of conclusions (Ibid.). By scrutinizing literature and conducting interviews some key challenges and opportunities that the industry faced were identified. This approach filters a number of challenges down to a couple of ones relevant for the scope of industrial custom-made apparel manufacturing.

5.3.1 Literature Review

The literature review served two main purposes of the thesis. The first one was to obtain an understanding of the fashion business. This included its present state, business trends, and challenges it is currently facing. The second purpose was to gather frameworks around which the empirical findings could be structured to enable a cohesive analysis. Databases used for data collection were Google Scholar and Chalmers' library's digital platform, which were chosen based on their amount of publications and accessibility. Initial searches were made to get a wide industry perspective, and included key words such as "fashion trends", "e-commerce" and "fashion retail". Later, this was narrowed down to "on-demand fashion manufacturing", "custom-made fashion" and "mass customization of fashion" to increase focus on specific technology, challenge areas and opportunities in the fashion industry. The literature sources from which information was obtained include books, e-books and articles. Moreover, industry expertise was considered to bring crucial information to the project, which later was applied to operations frameworks. This information was acquired through scrutinizing published industry reports and homepages. Essential industry information was obtained from these, including market trends, market drivers and statistics.

The fashion industry is a fast-moving industry which means information can be outdated quickly (Hagberg et al., 2016). Therefore, finding recent industry reports was of paramount importance. Furthermore, the information was useful to confirm or reject research findings between research and real market occurrences. On the other hand, one must be careful how this secondary information is presented (Bryman and Bell, 2011). Industry reports might have a business interest and hence, the data might be biased in different ways (Ibid.). Utilizing this information has both advantages and disadvantages (Ibid.). It can save a lot of time and cost and is often of high quality (Ibid.). On the other hand, it can difficult to obtain an in-depth understanding of how and what particular data that has been collected (Ibid.). Lastly, researchers basing studies on secondary analysis data have a low ability to influence the data quality (Ibid.). Therefore, where, when and by whom data sampling was carried out determined if the information was considered useful or not.

5.3.2 Interviews

The empirical data collection was designed to facilitate the exploratory research approach. As opposed to explanatory research, which aims to explain a certain topic, exploratory research focuses on exploring a certain topic to gain deeper understanding (Bryman and Bell, 2011). The rationale behind conducting interviews as a part of the data collection activity was to obtain essential empirical data from the industry. They were carried out with industry representatives and were of semi-structured nature. According to Bryman and Bell (2011), this approach facilitates qualitative research since interviewees are given room to provide information beyond answers to questions posed explicitly. Moreover, the interviewer has the ability to prioritize and let the interviewee expand on more important areas of discussion, rather than strictly following a questionnaire. As opposed to unstructured interviews, results from semi-structured interviews allow for some degree of comparison (Bryman and Bell, 2011). The questionnaire was designed with some general industry questions to test pre-collected data and some specific questions which had essential contribution to the project. Regarding how the interviews were conducted, the ones with Cavaliere, Eton and ACG Nyström were conducted in person whereas the interview with John Henric was conducted over telephone due to distance constraints.

By involving fashion industry representatives and discussing practical challenges in the industry, applicability of research models was facilitated which improved overall insights of the thesis. Also by involving industry experts, success stories that can be of significant to the project can be revealed (Pulliam and Stawarski, 2016). This was of particular interest since the thesis takes place in a setting of new innovation and hence, the information collected was used as benchmark. However, Pulliam and Stawarski (2016) also highlights drawbacks of interviews as a means of collecting data, arguing that it is a relatively time consuming process, both in terms of preparation and execution.

To ensure interview quality, guidelines from Bryman and Bell (2011) and Pulliam and Stawarski (2016) were used. These guidelines include five key activities that was executed prior to the interview. Based on the research purpose, interview questions were formulated to fit the semi-structured approach. The second activity included questionnaire testing with five project externals to confirm understanding and rephrase unclear or overlapping questions. The third activity was to prepare the interviewers. This was done by sending out an outline prior to the interview where the interviewees had the opportunity to consider if they had the right knowledge to contribute to the project purpose. Next, the fourth and fifth activities were carried out, which was to provide clear instructions and schedule the interviews. The instructions included expectations and data use conditions of the interviews whereas the scheduling was to plan the interviews accordingly.

Cavaliere was considered an interesting company because it is a well-known brand owner offering custom-made suits as a service in its business. Moreover, the suit, with its high amount of parts and measures, is a highly complex garment to manufacture. Thus, Cavaliere was considered to make a good contribution to the project to illustrate custom-made aspects. The second brand owner was Eton, which has come comparably far in offering premium shirts with customization possibility. Moreover, shirt customization is experienced to be a top segment of apparel with customization possibility. The third fashion company that was involved in the empirical data collection was John Henric. Contrary to the first two firms, John Henric does not offer custom-made apparel. It was involved in the empirical data collection to obtain insights in bulk manufacturing. By involving John Henric, their view on custom-made fashion nuanced the data collection and contributed with another perspective. When theory and empirical findings were iterated, it also became apparent that the operational differences in production between bulk and custom-made were minor. Moreover, these three brand owners gain insights from both market and production,

Overview of interview participants			
Name	Firm	Title	Category
Maria Frick	Cavaliere	Owner	Premium suits
Maria Johnson	Cavaliere	Custom-made expert	Premium suits
Henrik Sämhag	Eton	Product Manager	Custom-made shirts
John Ekström	John Henric	CEO & Founder	Shirts & accessories
Thomas Arvidsson	ACG Nyström	Vice managing director	Production Technology
Robert Olsson	ACG Nyström	Vice managing director	Production Technology

Table 5.1: Interview table containing selected interviewees representing fashion industry.

which are two interrelated elements of determining the attractiveness and feasibility of custom-made manufacturing. Furthermore, ACG Nyström was involved to identify and understand limitations in technology. This provided insights into both demand for new technology as well as the ability of current technology. Lastly, the interviews with Cavaliere and ACG Nyström were each held with two firm representatives as shown in table 5.1. This was a request from the firms and the motivation behind this was that they had different areas of expertise, and therefore could provide a more holistic perspective together.

5.4 Research Quality

This section on research quality comprises four subsections: Validity and reliability (5.4.1), Credibility (5.4.2), Transferability (5.4.3) and Ethics (5.4.4). Together, these chapters demonstrate thesis quality across the four stated dimensions (Bryman and Bell, 2011).

5.4.1 Validity and Reliability

Bryman and Bell (2011) presents two different types of validity: external and internal validity. Internal validity refers to the degree of causality between developed theories and research observations (Ibid.). Aspiring to achieve high internal validity of findings, the authors have attempted to maintain a neutral attitude to whether custom-made manufacturing actually is a solution to identified challenges. When data collection was conducted, advantages as well as disadvantages were included. If the project is externally valid, it means that insights can be generalized beyond findings (Ibid.). Hence, the data sample, which the research is built upon, must be representative (Ibid.). This has been managed through engaging with experts in the field as seen in 5.1 and scrutinizing various data sources. Also, when contradictory information has been found, it has been presented to increase trustworthiness.

Just like validity, reliability can be divided into external and internal (Bryman and Bell, 2011). Here, external reliability refers to replication (Ibid.). This means that one should be able to achieve same results with same methods but with other subjects. Bryman and Bell (2011) argue that this is specifically challenging for qualitative research since it is not possible to freeze a social setting and replicate the experiment as it was conducted originally. Internal reliability refers to whether there are multiple team members sharing the same view of developed theories (Ibid.). This was not seen as an issue in this case since empirical findings pointed in a uniform direction.

5.4.2 Credibility

Bryman and Bell (2011) equate credibility with internal validity, describing it simply as how believable the findings of a study are. Patton (1999) argues that the credibility of a qualitative study hinges on three interrelated elements:

- Collection of high-quality data that satisfies requirements on validity, reliability and triangulation, and can be analyzed meticulously
- The researcher's credibility, which in turn hinges on, among other things, his or her experience, status and track record
- Aspects of more philosophical character, such as one's appreciation of qualitative inquiry, methods and analysis, and holistic thinking

During the duration of the thesis, attempts have been made to mitigate the disadvantages of limited industry experience. Insights gained from numerous interviews with industry professionals as well as a continuous dialogue held with a knowledgeable supervisor have helped this cause. The extensive literature review carried out, in combination with the linkages made between it and the data collected through interviews, has also had the aim to elevate the credibility of the study. This is in line with arguments made by Bryman and Bell (2011) that "a competent review of the literature is at least in part a means of affirming one's credibility as someone who is knowledgeable in a chosen area".

5.4.3 Generalizability

Generalizability is defined as "the extent to which observations or theories derived in one context can be applicable to other contexts" (Easterby-Smith et al., 2015). When research results are generalizable, they are said to have high external validity, which is part of the reason why the selection of the research sample is crucial to guarantee a successful study (Bryman and Bell, 2011). Study of smaller samples, that seek to be as representative as possible for entire populations, is done since studying a whole population is often impossible due to time constraints (Kukull and Ganguli, 2012). Kukull and Ganguli (2012) underscore the necessity for a reasonable sample to be coupled with a valid estimate of properties of the population that is being studied.

5.4.4 Ethics

According to Bryman and Bell (2011) ethical areas that should be considered when conducting research are copyright, data management, reciprocity & trust and affiliation & conflict of interest. Regarding the interviews, data management and reciprocity & trust are important areas (Ibid.). This was handled as described in section 5.3.2; interviewees were informed prior to interview of the project purpose and how the data was planned to be used. The other areas were managed by having clear and consistent communication with parties contributing to the progression of the thesis work. Moreover, for sensitive areas such as data management, contracts were signed to clarify conditions. Lastly, transcripts were sent out to interviewees individually after the interviews, in order to confirm data sample and have the opportunity to exclude potentially confidential information before its release through the publishing of the thesis.

5.5 Method Summary

This chapter has broken down, and given a rationale for, the different steps taken in the execution of this thesis project. Given the relative novelty and uncertainty characterizing the research area, arguments have been made for applying a qualitative research strategy, coupled with semi-structured interviews for data collection. Additionally, the literature review has been explained and the choice of interviewees has been motivated. Finally, different aspects of research quality have been discussed.

6
Empirical Findings

In this chapter, the result of the empirical findings are presented. The chapter begins with a brief introduction to the roles assumed by the different actors in the fashion industry. Next, findings from the interviews conducted during this thesis project are presented. In this section, the data collected through each interview is presented separately. Every subsection is initiated with a brief company presentation, where firm characteristics are highlighted to provide the reader with a picture of what each company's role in the industry is. For the brand owners interviewed, their respective processes for producing apparel of their standard selection and custom-made is also presented separately. The chapter is concluded with an overall summary of the empirical findings.

6.1 Introduction to Industry Structure

The fashion value chain, like that of any industry, has numerous roles that each have their own tasks and challenges, and are adopted by different players. A brief explanation is provided to each of these roles and their functions in the market, as defined and henceforth used in this thesis. The ambition is to establish terminology in order to avoid ambiguity during subsequent narratives and discussions, and to familiarize the reader with the structures and dynamics of the industry, before diving deeper in the issues that lay the foundation for this project.

- **Consumer** is defined as the product buyer. The consumer typically interacts only with the party where product is purchased, which can be a *retailer* or a *brand owner*.

- **Retailer** can design apparel and/or sell from a variety of brand owners as a wholesaler. This entity can be handled either directly by a *brand owner* handling their own sales, or an independent player selling a variety of brands, e.g. Ströms.

- **Brand owner** has its brand on the apparel. The role can also undertake design tasks, like Eton does for example.

- **Material suppliers** are the actors who supply the fabric used for production of apparel.

- **Technology suppliers** provide technology for production, which can be both hardware and software technology, e.g. ACG Nyström.
- **Producers** manufacture garment. These could be independent producers or owned by brand owners.
- **Logistic providers** handle the transport of goods between players. Typically a third party logistic player.

The different roles defined above are visualized below in figure 6.1. The numbers in the figure show the sequence of the steps in the value chain, which starts with the customer placing an order, and ends with the customer receiving the finished product. For the different roles, examples of individual or typical actors are given in italics.

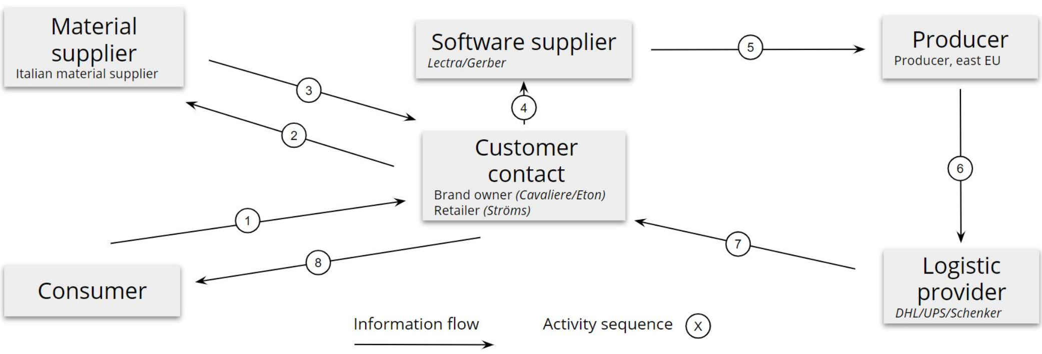

Figure 6.1: Interaction between different actors in the value chain for custom-made apparel.

6.2 Interviews

The firms that have participated in the data collection are introduced below. Some key characteristics for each firm are presented to give the reader some background information before deep diving into operational insights.

Apparel manufacturing has been distinguished to two different areas: bulk and custom-made. Bulk manufacturing presents how interviewed firms manufacture their apparel made-to-stock. In other words, they are not customer specific and instead, apparel design follows collection or standard product lines. As opposed to bulk manufacturing, custom-made production is made-to-order manufactured apparel based on customer input regarding design.

6.2.1 Cavaliere

Cavaliere is a family owned fashion brand owner founded 1973 in Borås, Sweden. Ever since the beginning, the firm has been determined to supply men suits of top quality (Cavaliere, 2018). Later, the firm has also entered the women's market by supplying women with premium apparel. According to Cavaliere (2018), it is a first tier fashion brand owner with the ability to supply everyone looking for premium fashion.

According to the firm, a premium suit is one of the most complex pieces of apparel to manufacture due to its structure, number of pieces per garment, measurements and different materials.

6.2.1.1 Bulk Manufacturing

Cavaliere's factory in the Czech Republic employs about 100 people, and has an output of approximately 160 suits per day of their standard selection, which internally is called the production collection. The firm designs new collections year around, both in Sweden and in the Czech Republic, and typically releases two spring collections, two autumn collections as well as one wedding collection in a year.

The development of new items for the standard selection begins with Cavaliere purchasing fabrics from their suppliers, of which about 90% are Italian. New garments are then created, usually by modifying features such as cuffs, pockets and seams on items from previous collections. The firm uses data tables containing the measurements of all such features for garments of different sizes to ensure uniform proportions across their product range. After this, a single sample is produced for inspection. Necessary changes are then made before samples in every size are produced. After these samples have undergone final inspection and refinement, the item is ready for full-scale production.

At the Czech site, different pieces of garment are processed at separate, designated production lines. For bulk production, the fabric for multiple garments of the same size and type are stacked on top of each other and cut out simultaneously. The cutting is done automatically, but the machine requires an operator to put the material in place beforehand. The subsequent sewing of the material into complete garments is also done manually. While labour-intensive production is usually moved to countries with lower wages and less prevalent trade unions than the Czech Republic (typically in Asia), the interviewees at Cavaliere argued that the quality of their products is too important and can not be compromised. They had previously experimented with some Chinese producers, but found that it had generated too many reclaims, long lead times and comparatively high logistic costs. From the producers' perspective, the production volumes were also not considered big enough to make it worthwhile.

6.2.1.2 Custom-Made Manufacturing

Cavaliere has a dedicated custom-made department offering full customization including made-to-measure features. It produces about ten suits per day, compared to the approximately 160 suits of the standard selection. Custom-made suits are sold through retailers who take the customer's measurements at their store and send them, along with the customer's unique design choice, to Cavaliere by phone or e-mail. Cavaliere then sends the measurements back to the retailer for confirmation, before submitting the order of the suit to the manufacturer in the Czech Republic. The interviewees stated that this manufacturer is independent and not owned by Cavaliere, as opposed to the manufacturer of standard selection suits.

Once the Czech producer receives the measurements, they are converted to coordinates mapping out pieces of the suit in two dimensions. This map is then printed on paper, which in turn is used as a template for manually carving the sections of the suit out from fabric. At this point, the processing of the actual suit begins, and after separate production, all the pieces of it are finally assembled before being shipped to Cavaliere in Borås. From there, it is sent to the original retailer as soon as possible, where the customer can pick it up. From order to delivery, this process can take up to six weeks.

Despite a 94% share of production collection, the interviewees at Cavaliere strongly believe that custom-made clothing will only get bigger in the future. According to Cavaliere, companies that are not preparing for that scenario are jeopardizing their future business competitiveness. They have seen a noticeably higher customer value in custom-made clothing, giving examples of customers with unusual builds being overwhelmed when finally finding clothing they feel comfortable in when dressing in custom-made garments for the first time. Other advantages include customers not having to know their size, lower inventory levels, and higher margins. However, the interviewees also pointed out several challenges in producing custom-made suits, including customers demanding hasty delivery, uncertainties when taking measurements, difficulties in standardization, and fabric being used in a more wasteful manner when producing one single suit at a time.

6.2.2 Eton

Eton is a Swedish fashion brand that designs and sells men's shirts globally. In the very beginning it produced its own shirts, but now the production is sourced to another party. The firm is well-reputed for three characteristics: quality, creative innovation and versatile style (Eton, 2018). Over its 90-year history it has realized stable growth and is now present in 49 markets. Recently the firm opened up its flagship store and shortly thereafter it started its own digital store (Eton, 2018).

6.2.2.1 Bulk Manufacturing

Eton has their primary manufacturing operations dedicated to bulk production. The process is highly standardized where a close partnership with the manufacturer enables efficient operations. The process starts at the design phase where Eton's design department select fabric, often from Italy and pattern, which can be described as how and which parts are fitted together. As an example, chest pocket and cut away collar could be a part of a pattern. When the design step is finalized, the shirt is scaled into different sizes to ensure that the pattern looks good for the whole size range. Next, the sample is sent to the manufacturing site in Eastern Europe. Together with the sample, measures and BOM are provided through an IT-system specific for fashion production. When the manufacturing site has all information and material they need for the manufacturing process, the material must be screened to avoid irregularities. According to Eton, this process can save big costs and money since the value increases as the clothing is being processed. Next step is the cutting of fabric, which is an automated process where information from the IT-system is extracted and used by a cutting machine. This machine has the ability to cut several fabric layers at once at a high precision, which saves both time and resources. As the pieces are cut, they are manually put together at working stations. These stations are specialized for specific sewing activities to make the assembly process more efficient. For instance, one station focuses on cuffs, another one on collars and so on. When the shirt is complete, tags are added, packaging is made and lastly, it is shipped to an inventory in Sweden before being distributed to retailers or sold on Eton's web store.

6.2.2.2 Custom-Made Manufacturing

Eton has a service called custom-made, which allows the customer to engage in the design process of their shirts. This service has turned out to be very popular, but in comparison with its bulk production it is still small. Factors the customer can influence is primarily design, but also to adjust the fit to a limited extent. This is limited because of two factors according to the interviewee at Eton. Firstly, they are offering a wide set of sizes. In addition to this, they also have four different fits called "bodies" for every size which makes the firm covering the mass market in a standardized way.

The process is initiated when the customer starts the design process at Eton's homepage. Here the customer can select between pre-defined variables, which can be selection of fabric, buttons and collar design. When the design process is finalized the order is confirmed by the customer. The order then goes through a number of Eton's computer systems in a stepwise verification process before it is sent as a production data file to the manufacturing site in Eastern Europe. Manufacturing activities involved in this process includes screening incoming fabric, cutting, putting the fabric pieces together and lastly adding buttons or initials. To cut the fabric according to measurements, it is manually placed at a machine where it is automatically cut according to instructions in the aforementioned data file. Sewing everything together is done manually at activity-specific stations with sewing machines. This means that every sewing station is specialized to sew a part of a garment e.g. cuff or collar. These working stations are not exclusively aimed for bulk or custom-made production, which means that these product categories share production resources. When the shirt is packed, it is sent to Eton's central warehouse in Sweden before sent to customer, similarly to bulk production. However, this process will be eliminated shortly. Altogether, from order to delivery, the process can take up to four weeks.

Eton states that offering a custom-made service is currently more labor intensive across the whole creation process compared to bulk production. According to Eton, measurements must be carefully taken by store associates to get everything correct and keep a professional touch and avoid mistakes that could be made by customers should they take on more responsibility in the design process. Even though it is not Eton's responsibility, they want to maintain a top of the line reputation and therefore they do this to prevent mistakes later in the value chain. Additionally, the production process requires the workers to leave their working stations to go and get material that is not located at its working station. This process is considered wasteful since it can be relatively time consuming. However, discounting the effort required to look for and collect material not by the working station, the manufacturing process for bulk and custom-made are equivalent with regard to complexity and time requirements. Additionally, Eton are able to utilize information from customized shirts by introducing variants that have been proven to be popular into their design of bulk produced shirts.

6.2.3 John Henric

John Henric was founded in 2008 to provide men with luxury accessories. Later, their product portfolio grew to supply men with a wider range of fashion accessories through its own stores and e-commerce site.

Compared to the other fashion brand owners interviewed, John Henric is a relatively small actor. Over the last few years, the company has implemented an offensive growth strategy which has proven to be successful. In the future, the firm has ambitions to become a prominent international fashion brand reputed for its premium men's accessories.

John Henric's key focus is to continue as a niche player within men's luxury accessories working directly with suppliers to achieve cost advantages Henric (2018). According to Henric (2018), its vertical integration strategy enables both a strong bargaining position and responsiveness to market conditions, which is another success factor. Moreover, the firm has managed to be flexible when it comes to establishing partnerships, facilitating efficient inventory management Henric (2018).

6.2.3.1 Bulk Manufacturing

John Henric has opposed to Eton and Cavaliere, a variety of manufacturing partners across Europe. According to the CEO, the primary reason behind this structure is the company's broad product portfolio sourced from highly specialized production sites. The production sites are external partners, which allows John Henric to continuously re-negotiate collaborations. Earlier, the firm had the majority of its production outsourced to Asia, but over time has shifted to Europe, reasoning that this improves the quality and cost at the sought volumes.

6.2.3.2 Custom-Made Manufacturing

John Henric currently has no custom-made manufacturing. However, the CEO expressed positive views on it, arguing that custom-made garments would mean higher product gross margins and lower inventory levels. The CEO also anticipates an increase in prominence of custom-made apparel as the prerequisites for custom-made processing improve. When asked why John Henric does not offer custom-made clothing today, the CEO responded that there is a considerable uncertainty when generating measurements for manufacturing of custom-made apparel, especially when this process is automated with technology. If the fit is unsatisfactory, this will have a big impact on the business by sparking increased product returns, negative customer reviews and no customer retention. Hence, the firm has chosen a passive approach by waiting until technology is more reliable before adding custom-made to its offering.

6.2.4 ACG Nyström

When discussing the ability to manufacture custom-made apparel at large scale, technology turned out to be a critical determinant. Thus, a fourth company with proven experience in textile production, ACG Nyström, was involved in the empirical data collection.

To present the company in brief, it was founded in 1921 as a sewing machine manufacturer and today it has a global presence in the textile industry as one of a few top players. Over the years the company has grown and their offerings expanded which today includes a variety of products and services required for manufacturing with fabrics. Its clients are some of the biggest manufacturers and designers in the textile industry, which ACG Nyström offers four different business areas: cutting, embroidery, textile merging and product life cycle management (ACG Nyström, 2018).

6.2.4.1 Technology

According to the interviewees at ACG Nyström, industrialized custom-made manufacturing faces two overarching challenges. The first main challenge is having the right production data, which includes measurement details and pattern fitting. Secondly, there are challenges concerning production capability. In agreement with their counterparts at Cavaliere and Eton, the interviewees at ACG Nyström explained that the uniqueness of custom-made parts makes the efficiency of the cutting process drop, since the cutting machine can not be loaded to full capacity. In addition to the cutting, the interviewees highlighted the complexity of handling textile, claiming that it is hard to automatize with robotics due to challenges in gripping. Two techniques frequently used for this is gripping with nails or vacuum technology. However, these solutions come with a risk of damaging the fabric. As a result, the textile pieces are often sorted and delivered to a sewing station manually. The material complexity of textiles also impacts the ability to automate sewing, which is the last step. Since the material handling is complex, this is currently done manually. Moreover, since labor costs are relatively low in countries with large-scale apparel production, the demand for automation is considered moderate. Consequently, there is also a moderate market demand for technology development.

There is also another complexity regarding customization of apparel. Primarily, when it comes to made-to-measure apparel, the pattern must change to make it look correct. This becomes an issue when scaling a size, and some kind of pattern adjustment is required to make parts fit correctly. If this is not done well, the apparel might look asymmetric. According to the intervieweees at ACG Nyström, there are three different ways to avoid this problem, of which the most common is to use an apparel design software. Alternatively, one can use algorithms or change the pattern manually. According to the interviewees, the first solution provides the best result. The algorithm solution may yield moderate results, but has a limited capacity to deal with extreme size variations. The last one is time consuming and requires skilled labor.

The interviewees at ACG Nyström also argue that the aspects of adoption, development and economy are closely interrelated. They also perceive the actual demand for products that stimulate industrialization of custom-made apparel to be low. Even though custom-made production seems to be very attractive and prominent in media, very few fashion players actually work with it. The interviewees estimate that only 2% of ACG Nyström's customers work actively with custom-made. Furthermore, the absolute market volume from these players is considered to have even smaller market share. According to the interviewees, this could be explained by different customer groups. As an example, millenials are more interested than other groups in customization. However, they are often not willing to pay for it, which makes it hard to motivate fashion players to invest in capabilities to produce such garments.

The interviewees explained that ACG Nyström has customers in a wide range of industries, arguing that manufacturing process with textiles is basically always the same thing, regardless of the area of application. Examples of customers beyond fashion were manufacturers of furniture and automobiles. According to the interviewees, the same equipment is used for cutting fabric for an armchair pad or an airbag as for a piece of apparel, with only minor software adjustments.

Lastly, the interviewees at ACG Nyström perceive many brand owners to consider their image very sensitive to customer dissatisfaction. As a result, they can be hesitant to implement new technology, since doing so unsuccessfully could damage their brand. Many of them expect that they stand more to lose from selling products of potentially compromised fit or quality than they do to win from appealing to the niche market of customers with unusual size. As a result, brand owners are waiting for other players to take a first move and by that gain experience to adopt best practice and mitigate risk.

6.2.5 Summary

To conclude findings regarding custom-made operations, figure 6.2 was compiled. It visualizes how the apparel customization ability of the firms stand in relation to each other and aims to clarify what roles the firms undertake. Even though the different firms are manufacturing different types of apparel they face similar design options. This means that no matter if you manufacture a shirt or a suit, fabric, pattern, the design options are alike.

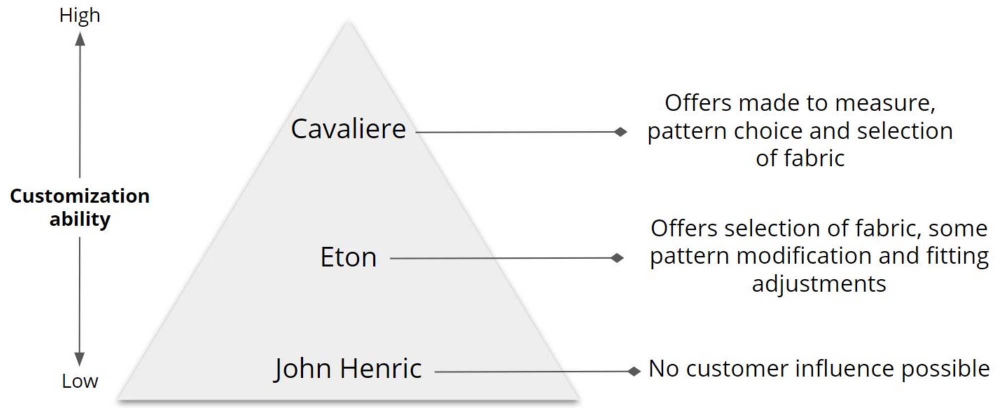

Figure 6.2: The figure visualizes how the apparel customization capabilities of involved brand owners stand in relation to each other.

Cavaliere is located on the top of the figure since it offers full apparel customization. This includes material, fitting and design. Cavaliere has defined some boundaries for the design but for every pattern they have several choices, which makes a great customization opportunity for the customer.

Eton is located in the middle of the customization triangle. To motivate its location, the customer has the ability to influence on a few options. These include fabric, collar cuffs and a few size adjustments. As stated earlier, Eton has made this choice to mitigate the risk of sizing and/or fitting flaws and jeopardize its reputation.

Lastly, John Henric does not offer the customer an option to direct influence on apparel design. Hence, John Henric is located at the bottom of the triangle.

It can be concluded that the processes for custom-made clothing and for bulk production have a lot in common, and only a few steps distinguish them from one another. Worth to mention, the first six steps in 6.4 shows the activities of new product development. This is performed every time for a custom-made garment in difference to bulk manufactured garments. To visualize what the respective processes may look like, the findings from the interviews have been summarized in figure 6.3 and 6.4. It should be noted that the steps in these figures have been generalized, and may not be completely accurate for each individual company, but will nevertheless give the reader an approximate overview for what the processes look like.

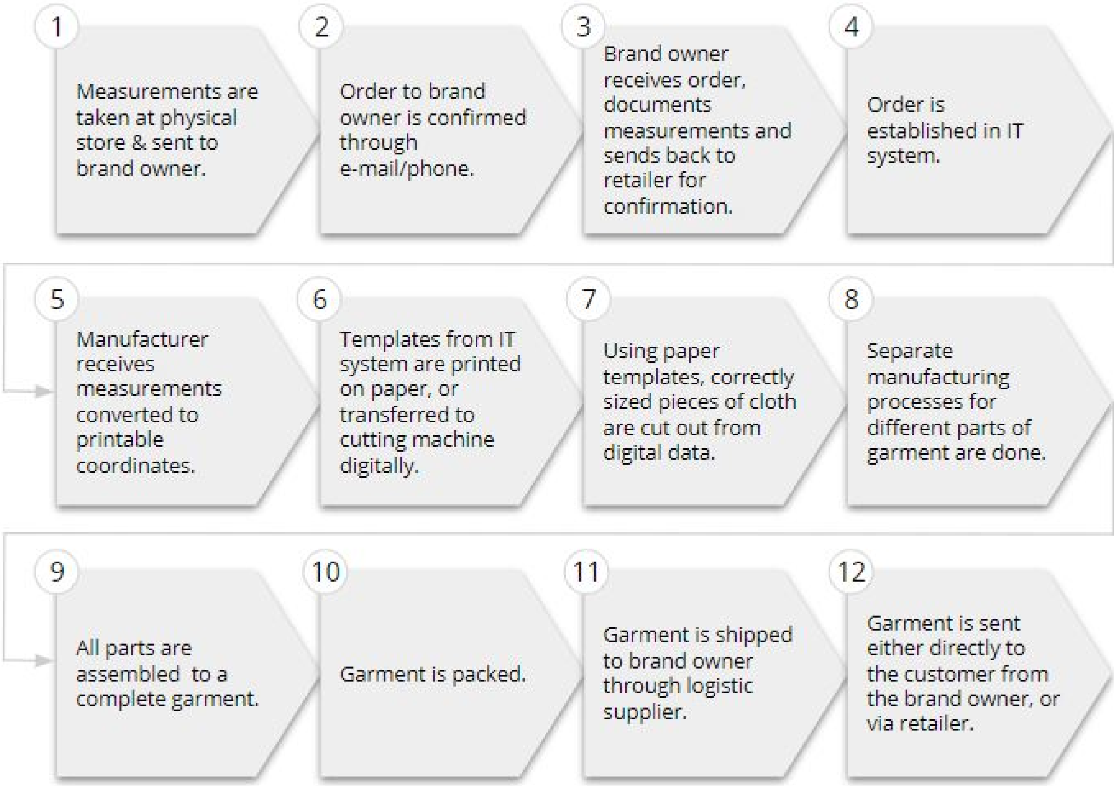

Figure 6.3: The figure visualizes approximately what the process for production of custom-made apparel looks like.

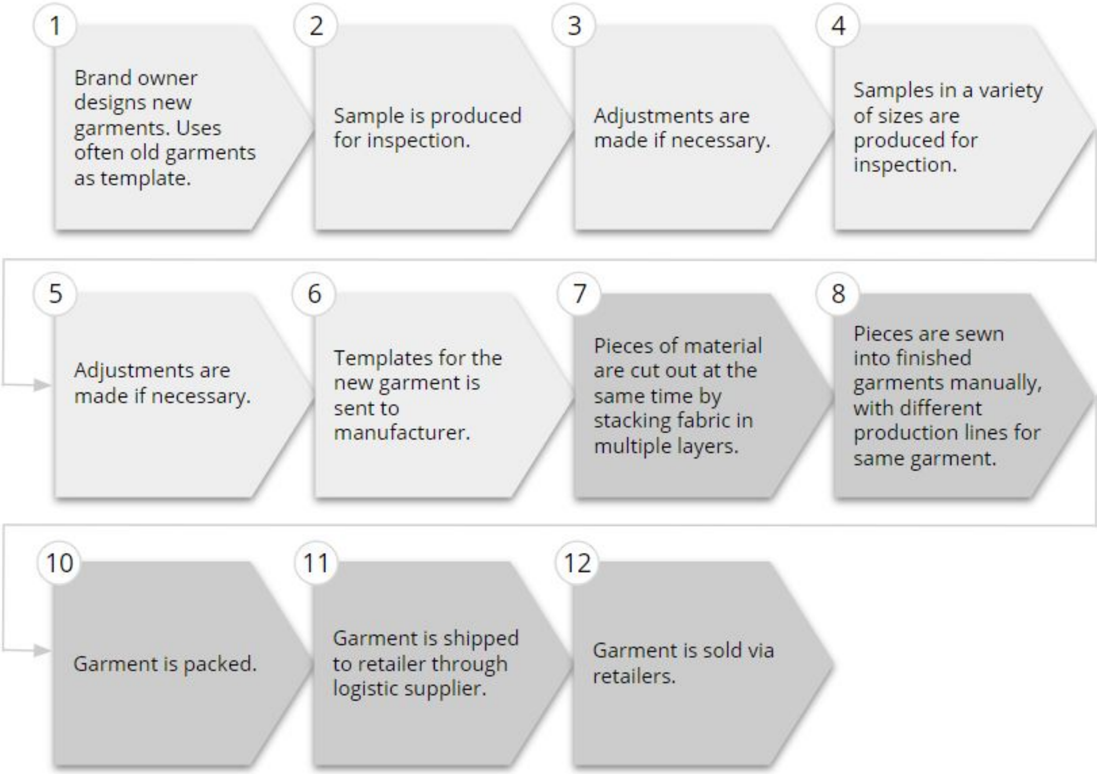

Figure 6.4: The figure visualizes approximately what the process for production of apparel of firms' standard selection looks like. Light grey shapes entails new product development stages.

7
Analysis

This chapter begins with an analysis of empirical findings. Here, the reliability of the data sample is discussed and motivated. This is followed by structured analysis where collected empirical data is synthesized and discussed. By connecting data collected from interviews with ideas and concepts acquired through the literature study, the research questions of the thesis are explored. At the end of the chapter, the analysis is summarized by attempting to answer each research question one by one in a structured manner.

7.1 Analysis of Empirical Findings

The empirical findings seem to represent a consensus to some degree, since all interviewees independently expressed similar views on the current state and the future of the fashion industry. In parallel, industry reports and theoretical models presented confirmed interview statements. The involvement of the technology provider ACG Nyström was yielding since the company is exposed to fashion technology developers upstreams and fashion designers downstreams. Hence, its contribution of knowledge was considered to encompass a consolidated view of multiple fashion stakeholders.

By comparing figures 6.3 and 6.4, it appears that the operational differences are small between the different business areas - bulk manufacturing and custom-made. Thus, the involvement of John Henric in the data collection was interesting due to its growth and operational structure, which differed slightly from those of Cavaliere and Eton. What could be argued is that the empirical data sample is relatively small. However, involved interviewees contributed with similar insights to the empirical data collection. Moreover, ACG Nyström with vertical and horizontal industry exposure clarified and confirmed insights from brand owners. Thus, it contributed with a consolidated knowledge from these players to the project. Lastly, it is possible that the findings are skewed toward characteristics of the premium segment, since the majority of interviewees were premium brand owners.

7.2 Operational Challenges for Industrial Custom-made Manufacturing

Custom-made apparel sets new requirements for fashion operations. It must be flexible, sustainable and supply the market efficiently as described in table 2.3. An agile approach is recommended to facilitate operational flexibility to address the custom-made demand, which can be related to the market winning factor service level, defined by Mason-Jones et al. (2000). Since custom-made apparel implies greater variety and lower predictability compared to bulk production, manufacturers may benefit from re-positioning their operations to support custom-made operations shown in 7.1. These new requirements are derived from operational challenges implied by industrial custom-made manufacturing. The arrow prompts the re-positioning if bulk production would change to custom-made production.

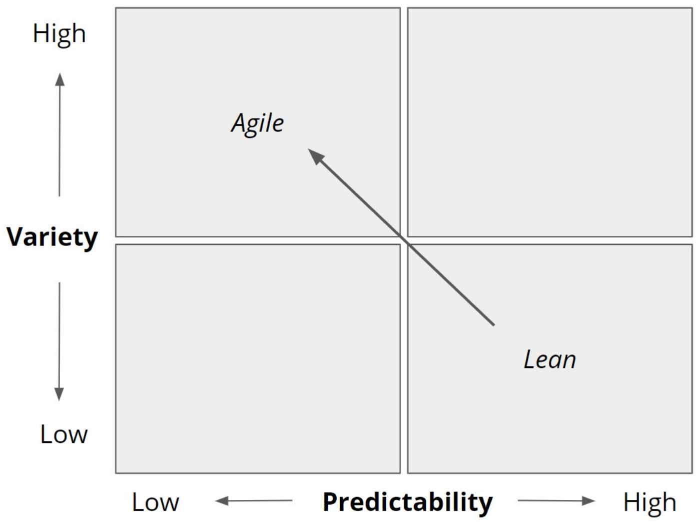

Figure 7.1: The figure illustrates key differences between lean and agile organizations (Christopher, 2000).

Regardless of the strong emphasis on handling increased product uncertainty, exclusively using agile methods is not recommended either since a lean approach also might benefit some operational activities (Naylor et al., 1999; Čiarnienė and Vienažindienė, 2014). Moreover, a key principle in lean is waste elimination. This will always be an important factor in achieving operational efficiency. Thus, it can be argued that firms would benefit from increasing agile capabilities to enable successful custom-made production, while still considering lean aspects where they are beneficial. As an example, tailors at Eton often need to go and collect material for custom-made apparel manufacturing since it is not available at the sewing station. This material collection process can be considered as waste since it does not create customer value directly.

The discussion in section 7.2 is structured according to the dimensions of the product-process matrix 4.9, defined by Slack and Lewis (2011). Challenges within the three dimensions presented to the left in the figure (coupling, automation and scale) will form a structure to the analysis for the identified challenge area 7.2.1. If these dimensions are set to its top respectively, firms will achieve superior flexibility capability. On the other hand, the operations are set to facilitate low volume production and have a high manufacturing cost per unit. If the dimensions are set to the very bottom respectively, operations is highly standardized to achieve cost efficiency, which is typical for lean operations. Thus, managing the balance between flexibility and cost is key to successfully enable custom-made apparel production. As shown in figure 7.2 it is possible for firms to build superior operational capabilities and thus decouple from the diagonal relationship. As stated by Slack and Lewis (2011), information technology enable decoupling from the diagonal. In the scope of apparel production, this could mean efficiently using information across the value chain to mitigate operational uncertainty. An example for this could be product demand information for production, supplied by retailers.

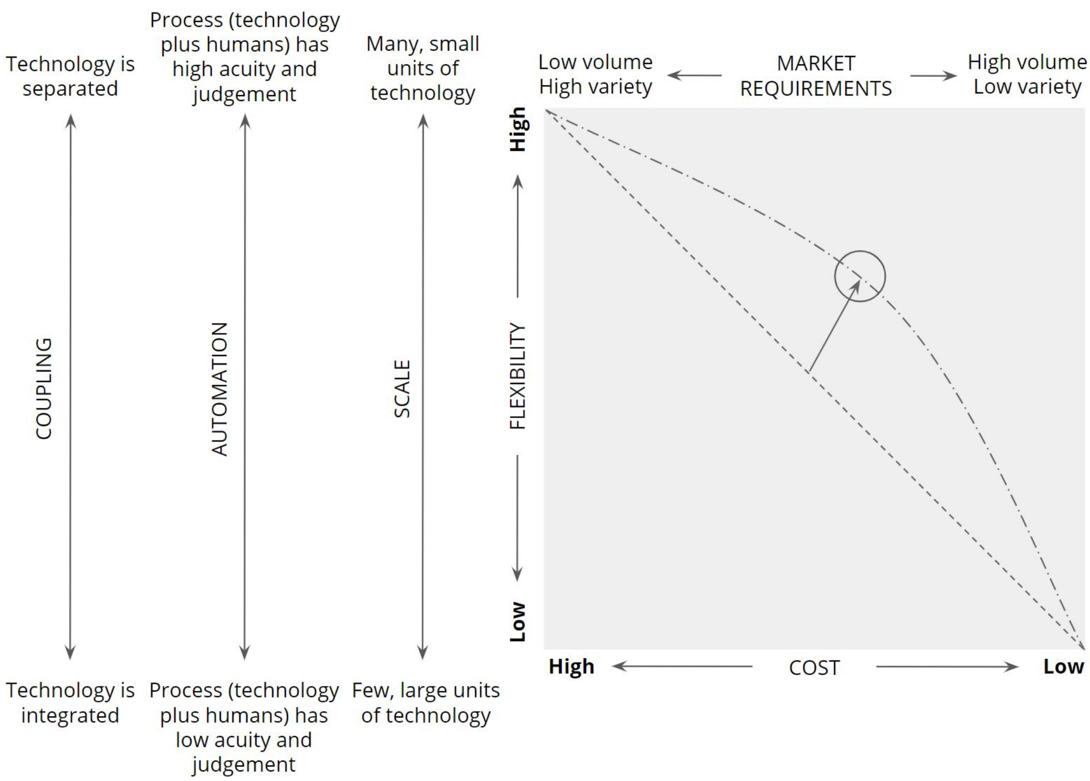

Figure 7.2: The figure visualizes an example of where organizations could position themselves to achieve certain operational characteristics (Slack and Lewis, 2011).

However, according to figure 7.2 the trade-off between cost and flexibility is still prominent. These are considered as two important factors and thus, apparel manufacturers must consider what operational capabilities they want to achieve. Interestingly, the figure also reveals a negative relationship between technology integration and flexibility, which is contradictory to theory about industry 4.0 in section 4.4. However, Bisio et al. (2018) emphasize technology that enable increased information sharing across the value chain. Through this, increased flexibility within the value chain can be achieved. Thus, these new trend can elevate operational capabilities to become even more efficient by integrating appropriate technology.

7.2.1 Operational Capabilities

A recurring element in the collection of empirical data was different technological barriers to launch custom made apparel production on an industrial scale. In particular, the fact that production of apparel requires a high degree of human involvement was brought up unanimously by the interviewees.

The first dimension scale describes the capacity of each unit. Since the production of apparel is perceived as complex, units have in general low capacity. An area where economies of scale can be achieved is the cutting process, where many fabric layers can be stacked and cut simultaneously. When moving to custom-made apparel operations it can lead to more unique items compared to bulk manufactured fashion. Given this scenario, it might impact on the economies of scale advantage that can be achieved by having standardized processes. However, it would be possible to achieve same cutting efficiency with customization excluding measurement adjustments. As an example, customers could engage in the design process by selecting different textile features such as fabric type and button color. This would only imply changes at the sewing stage which already is done manually. An alternative is to combine different fabrics for the same product. Compared to bulk produced apparel, the CODP would be moved to the left since there is a bigger uncertainty regarding what items the product will constitute of. Thus, firms should strive to make the product customer specific as late as possible to be able to standardize production and manage inventory efficiently.

Moreover, custom-made production sets new requirements of today's supply chain. Essentially, products that are custom-made are customer specific. This implies that every product will have a determined customer once it leaves the manufacturing site. In difference to other bulk produced apparel that are produced in forecast sized batches where economies of scale is strong economic incentive. Moreover, these batches can be sent to logistic hubs for further distribution. Since delivery time was one of top rated factors of what matters to online customers, products should be sent as soon as finished from a customer perspective (Berg et al., 2015). However, this operational approach is not possible in the same way for custom-made. This would lead to distribution inefficiency for custom-made since it is more expensive to ship items one by one rather than shipping a batch. According to the interviews, the majority of premium fashion is manufactured in east Europe and large volume production takes place in Asia. If Sweden would be the end market and manufacturing stays at today's location, distribution costs will constitute a significant share of the total product cost because of a long item specific shipment. The question would then be if it is possible to move manufacturing close to the end consumer. Here, the empirical findings confirm the conclusions drawn by Berg et al. (2018) regarding technology automation maturity in apparel industry. Thus, it is considered to take some time before nearshoring and complete apparel automation

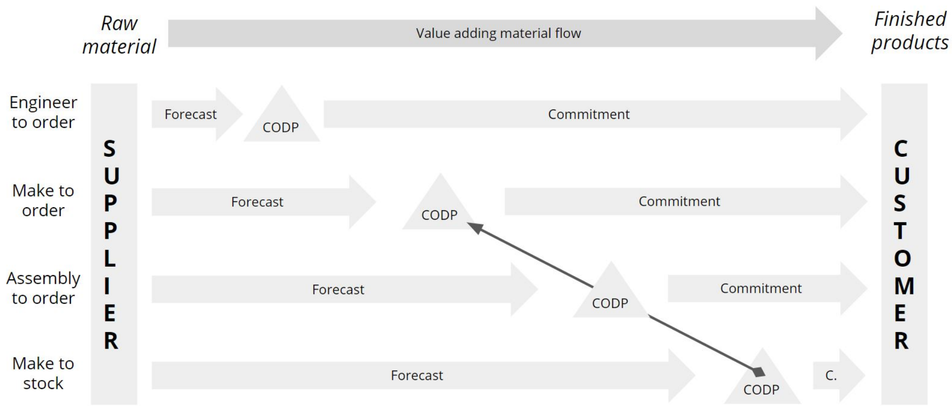

Figure 7.3: Production of custom-made apparel will move the CODP to the left since the products will be more demand driven (Christopher, 2000).

is enabled.

When dealing with product customization it can not be planned to the same extent as for bulk production that is produced directly to inventory based on forecasts. As described by Christopher (2000), apparel producers must move the CODP to the left to enable customer involvement in the design process. In this case, the CODP is likely to be positioned at "Make to order"-level or, with less customer involvement, "Assembly to order"-level. As a result of customization, final product inventory size and production complexity is likely to increase.

The interviewees at ACG Nyström explained that the production technology has some critical limitations that hinder the ability to automatize. The key issue here is the complexity for robots to handle fabrics automatically and thus, a high degree of human involvement is required as the technology is today. This does not only impact automation possibility at each stage, but also the coupling ability between production stations, such as between cutting and sewing. There was a uniform opinion expressed by the interviewees concerning inherent complexity of the fabric material properties, which makes it hard to handle.

Another challenge frequently mentioned during interviews was the complexity of creating patterns for custom-made apparel. There was a uniform understanding by all interviewees that the creation and change of pattern is a complex process. As mentioned by ACG Nyström, this process is not fully automated yet and is required to work efficiently to provide industrialized custom-made apparel.

The last dimension presented by Slack and Lewis (2011) is coupling and is described as the extent to which technologies are linked together. The issue of increasing coupling between operational activities was described as prominent during the empirical data collection because of several factors. Firstly, process technologies were not compatible with each other. As an example, Cavaliere uses phone, paper and a digital system in parallel in the manufacturing process. Moreover, as earlier described, the production technology requires human involvement to a high extent due to material complexity, which means that coupling ability is complex.

For bulk production, the extent of coupling was perceived as better compared to custom-made manufacturing. Since lead time between order to final delivery is a critical factor according to Berg et al. (2015), this lead time should be minimized. Additionally, demand driven apparel production will limit the ability to produce to inventory. Therefore, it will be critical for apparel manufacturers to possess technology that can deal with flexibility and still satisfy customer delivery lead time requirement.

Given the hypothesis that automation is the direction to enable industrial custom-made apparel, it exist a variety of operational challenges. Even though the interest and advantages that might arise from this production concept are prominent, it seems that its not enough to position the performance of technology to meet operational requirements of custom-made apparel as it is today.

7.3 Reasons Behind Challenges

Having synthesized the interview findings to explain what challenges exist in producing customized apparel on an industrial scale in section 7.2, this following section will dive deeper into *why* such challenges exist. In other words, this section will attempt to explain the underlying reasons behind the challenges presented above. This analysis has been made possible by the interviews conducted during the project. Without the insights gained from these interviews, it would have been very difficult to grasp and analyze the complex interrelated issues characterizing the dynamic fashion industry.

7.3.1 Labor Asset

The interviewees underscored the fact that due to the limitations in technology (presented in 7.2), apparel manufacturing is a labor intensive endeavour. Thus, access to labor is of paramount importance not only for manufacturers, but also for brand owners to ensure right quality and attractive production cost.

Both the introduction data 2.4 and empirical findings 6.2 points that manufacturing takes place in Eastern Europe or Asia and the motivation behind this is because of three driving factors. First, as previously described, apparel manufacturing is labor intensive and hence low wages are desired. Second, the distance to material also takes place about these regions. Third, there is an old tradition of manufacturing apparel in these countries, where it over time has built strong prominent industry knowledge. As a result, the access to skilled labor here is good.

7.3.2 Technological Barriers

Bisio et al. (2018) argue that the aim of industry 4.0 is to enable real-time internet interaction among production resources, facilitating efficient communication between all connected parties. With the data from interviews with different actors in the apparel industry showing that communication oftentimes takes place across multiple steps over phone, e-mail and different IT-systems, it thus appears clear that this business has not yet entered the era of industry 4.0. This would confirm the observation made by Rüßmann et al. (2015) that there are rarely close links between customers, suppliers and companies today. Rüßmann et al. (2015) further argue that extended integration allows increased flexibility and profitable production of smaller batches. Accepting this relationship, the lack of such an extended integration in the industry would then logically pose as a hindrance to customization of apparel on a large scale. This is also supported by the claim by Zhong et al. (2017) that there are currently challenges in producing high quality, highly individualized goods with short lead times, which industry 4.0 will help companies overcome.

One of the interviewees also commented that the main technology suppliers in the industry could use a little competition, indicating that not enough effort is made to make progress by existing actors. Additionally, attitudes like this could be argued to show a lack of collaboration and responsibility for driving change in the industry, which contrasts the need for collaboration emphasized by Tjahjono et al. (2017). The effects of inadequate collaboration are accentuated when juxtaposed with arguments by Lehmann et al. (2018) that industry 4.0 has the potential to create entirely new business models in fashion, but requires firms joining forces for this to happen.

7.3.3 Waiting Game

One major problem in custom-made apparel expressed during several interviews is the risk involved with being the first actor to try new technology. According to the interviewee at Eton, they are curious about new technology, but careful about experimenting with their offering. According to him, they have to weigh the benefits of new technology against the risk of outcomes that could potentially damage the brand, which they value very highly. Because of this carefulness, they, like other established actors, most often opt not to experiment with unproven technology. Several interviewees were very aware of technology trends in the industry and what their competitors are doing, expressing a belief in the importance of innovation in the industry and a will to adopt technology that has proven successful. This reasoning goes in line with arguments made by Jensen (2003) that new technology often brings free-rider problems when actors are hesitant to adopt new technology, opting to wait for peers to try it out first. Actors waiting for others to make a move first appears to be a general trend in the industry, as the interviewees at ACG Nyström also pointed at an unwillingness among its customers to take risks by being the first to adopt new technology. Therefore, one could anticipate that it builds a catch-22 scenario that hinders technology diffusion.

It has been established that the apparel industry is under evolution, with customer preferences and other aspects changing swiftly, and therefore there is high uncertainty, which makes a waiting game more likely to happen, as argued by Robinson et al. (2012). According to ACG Nyström, the most innovative firms in the apparel industry are often smaller less known actors or mid-sized established brands.

7.4 Opportunities in Fashion Industry

Given custom-made, on-demand manufactured apparel is an approach to address today's fashion industry main challenges, new opportunities in the value chain are likely to emerge. New conditions can also imply that roles are not only exchanged, but also the whole value chain might be disrupted, where roles are eliminated and added to current value chain as stated by Lehmann et al. (2018). To present these new opportunities in a structured manner, Lehmann et al. (2018) value chain framework 7.4 is used. Three major areas have been identified to possess opportunities given custom-made apparel business. These major areas are shaded as seen in figure 7.4, as presented below. On top of these areas, key trends are presented, which will be presented more in detail in this section.

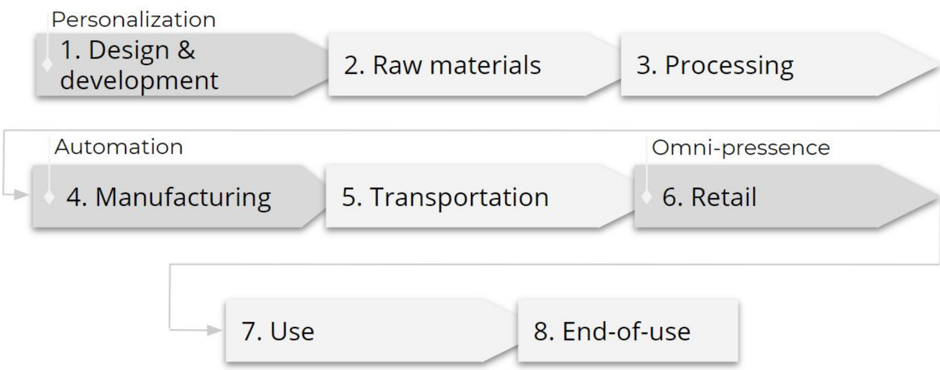

Figure 7.4: The figure visualizes opportunities in the fashion value chain that can emerge given that industrial custom-made apparel manufacturing will take place.

As market express a need for product customization, one could expect new technology providers will take part of the fashion value chain to respond to flexibility requirements. As described by Rüßmann et al. (2015), to cope the flexibility efficiently, the importance of information sharing vertically- and horizontally must increase. As a result, stakeholders must decide how, but also what information to share to make this information flow lean. Moreover, the importance for this is likely to increase since dependency between stakeholders will increase due to product complexity and necessity of short lead time. According to Slack and Lewis (2011), information technology is an enabler that can support organizations to achieve both flexibility- and cost advantage, as stated shown in 7.2. Preferably, a standardized system should be deployed for the whole value chain to achieve process control, which can facilitate the production of custom-made apparel.

The AR-technology can enable highly efficient body scanning, which can result in highly valuable databases with information not only relevant for fashion industry, but also other industries where product and body cooperate. In fashion industry this could not only facilitate shopping experience by showing products digitally, but also mitigate risk by supplying right size. As a result, return rate can potentially be mitigated. Body information could also benefit other industries. An example is chair ergonomics in a variety of industries could be optimized based on empirical data. The extent of data use is limitless since it is highly applicable cross industries and product categories.

Based on Čiarnienė and Vienažindienė (2014) fast fashion theory, multiple similarities can be found based on the characteristics of custom-made fashion. However, three characteristics appear to be more prominent for manufacturing of custom-made apparel than other, shaded in figure 7.5. Firstly, the issue of consumer driven is inherent in the concept of customized apparel. Contrary to fast fashion, collections are evaluated based on market data, custom-made apparel will be produced based on real-time information. Thus, this issue is critical in the scope of custom-made apparel. Secondly, production runs will become even shorter compared to fast fashion production due to product customization. Thirdly, the information flow is critical to work efficiently and thus, a friction-less communication flow between players is necessary to realize custom-made. Hence, the third issue is partnering and network. Altogether, it facilitates the value chain to cope increased value chain uncertainty in terms of flexibility capabilities.

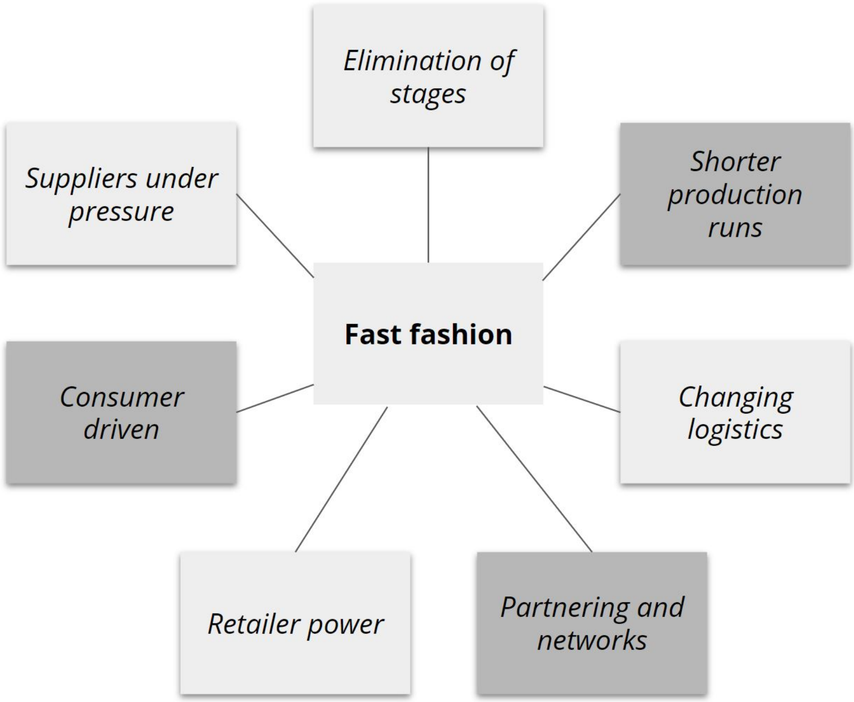

Figure 7.5: According to Čiarnienė and Vienažindienė (2014) fast fashion has seven key characteristics illustrated above, where the three shaded are seen as most critical for industrial custom-made fashion.

7.4.1 Design & Development

Based on industry reports presented in section 2.3, one apparent industry trend is that customers demand more personal products to express themselves to a larger extent. Thus, to offer this demand at large scale, customers must have the ability to engage in the design process. Some first movers offer customization to a limited extent. One could expect that similar solutions will emerge on the market as technology is getting cheaper, and the supply chain has the ability to cope increased product uncertainty. Thus, service technology around this trend will grow.

Moreover, customization of apparel in terms of made-to-measure is likely to increase because of several reasons. Firstly, it can address the need for personification e.g. guarantee best fit. Secondly, it has the potential to improve operational inefficiency as described by (Christopher et al., 2004), which had an average -25% contribution on total revenue compiled in table 2.5. To conclude, if custom-made, including made-to-measure, can be offered at an attractive price at large scale, it is likely to dominate the future of fashion market. As it is today, technology is bottleneck for the design and development phase and thus, there is a large potential in making it ready for industrial custom-made manufacturing. More particular, the prerequisites for collecting information must be established. Here AR-technology is a potential solution for collecting information in an interactive way where a custom-made product can be virtually tested before manufactured.

As suggested by Wheelwright and Clark (1992), mass customization can be efficiently enabled by deploying platform- and/or modularization strategies. This could postpone the CODP and achieve product customization at the same time. To take advantage of such strategies, redesign of apparel might be necessary. Thus, a close collaboration between designers and manufacturers is considered critical. This statement is a practical example of what Lehmann et al. (2018) mentioned about increased industry collaboration, stated in 2.1. This strategy brings two advantages. Firstly, the production of apparel can be standardized to a larger extent. Secondly, production is less dependent on orders compared to a case when the product would be produced customer specific from first process step.

7.4.2 Manufacturing

Based on the collected information, fashion manufacturing is not yet mature to undertake automated custom-made manufacturing. Applied to the fashion context automatic handling of fabric is the key issue, as stated by ACG Nyström among others. Automatic handling of fabric does not only improves the processing of the material itself in a specific machine in terms of human involvement. It also enables coupling between several stations, which in turn has the potential to reduce lead time and required human involvement. By solving this issue, the manufacturing process of custom-made fashion is close to be enabled at an industrial scale. Aligned with Bisio et al. (2018), technology can aid manufacturing in multiple parameters, industry 4.0 is an interesting concept. It is said that the concept can increase flexibility by integration, which is recommended for the custom-made manufacturing process. However, just as Xu et al. (2018) says, industry 4.0 concepts often fails because of lack of powerful technology, and unfortunately, custom-made apparel seems to not be an exception. Since the drivers of apparel manufacturing location are knowledge and labor cost, automation has the potential to disrupt this rationale. This means, that if automated production is enabled, nearshoring is possible and thus, transportation costs can be decreased and carbon footprint be mitigated.

Manufacturing of custom-made apparel can improve environmental aspects in terms of material use and product life length as stated by Berg et al. (2018). The opportunity here is to provide the market with the right production volumes that are enabled through data driven sourcing instead of today's forecast driven approach. However, given that the material still is of same characteristic, it will have a negative contribution. Hence, there is an opportunity for material suppliers to provide sustainable material for fashion production. As the younger population demand more ethical products, this might also be financially motivated. However, according to (Lehmann et al., 2018) continuous improvement across the value chain does not possess the real potential. Instead, it is disruptive innovation, such as application of elements of industry 4.0 and a collective industry effort, that foretells a sustainable future (Ibid.). Here, a disruption of material, nearshoring and market pull supply system could be key.

7.4.3 Retail

When it comes to product distribution, it can be concluded that multiple brand owners use multiple channels. However, the omni-strategy is often missing, which means that channels are run separately rather than supporting each other. Here, firms must know what they want to achieve and how to do it. Given the arguments by Kruh et al. (2018) regarding the increasing importance of experience per area unit as a metric, and the suggestion by Lehmann et al. (2018) to use augmented reality to enhance customer experience, adopting such technology appears highly relevant for fashion retailers. Implementing such technological elements into stores would also be a natural step towards bridging the gap between offline and online, hence facilitating the transition to omnichannel. By doing so, offline stores would also have increasing possibilities to collect more data efficiently, similarly to online retailers. As revealed by Hjort and Lantz (2016), returns are costly. Still it seems that many retailers use a poorly designed return strategy and as previously mentioned, profitability can be increased and carbon footprint from transportation be reduced if this is adjusted. Therefore, it is recommended to not only collect data, but also use it as a competitive tool to gain advantage. A solution to address complexity of positioning the return strategy is to offer custom-made apparel. According to Konsumentverket (2018), the right to return a product does not apply to custom-made products and thus, the return issue could be eliminated.

The launch of technology in the fashion business also has the potential to increase customer experience, which, according to Kruh et al. (2018), is a key desire for players in the industry today. Retailers would therefore benefit from investing in technology that enables customer experience as a part of the customer journey. Here, there is an opportunity for both retailers investing in customer experience, but also developers offering solutions that enhance the customer journey.

7.5 Research Question Conclusion

This concluding section of the chapter will summarize the presented arguments and insights from the analysis by connecting them to the three research questions presented in section 3.2. The ambition is to briefly and concisely remind the reader of the essential aspects discussed above before proceeding to the final chapter of this thesis.

7.5.1 Research Question 1

What can be operational challenges in industrial custom-made apparel?

The first research question deals with defining operational challenges in industrial production of custom-made apparel. There are a number of such challenges due to the great variety and low predictability of custom-made production compared to bulk production. There is a trade-off between flexibility and cost of production across the dimensions of connectivity, automation and scale, and given the need for flexibility in custom-made, there is an associated higher cost. Launching production of custom-made apparel on a large scale requires a mitigation of this trade-off by building superior operational capabilities.

The high degree of human involvement necessary for custom-made production was brought up unanimously during the interviews. Production of apparel in bulk is already characterized by a higher degree of manual labour compared to other areas of production, and it is evident that economies of scale are even less present in production of custom-made garments. This is due to features of fabric such as stretching and folding that makes it unpredictable during production, and the fitting of large patterned material that can become very complex for custom sizes. These challenges are often too complex for robots to deal with.

Custom-made production also brings new challenges from a supply chain perspective, since the receiver for each individual product is predetermined already when production begins. This means it has to be kept track of precisely throughout all of the value chain. Due to the high uncertainty involved, the CODP also has to be moved further away from the customer in production of custom-made apparel.

7.5.2 Research Question 2

What can be reasons for operational challenges in industrial custom-made apparel?

As for reasons behind the operational challenges in industrial custom-made apparel, several have been identified and presented. As established, production of apparel is a very labour-intensive enterprise. This means there is a need for a large pool of competence and preferably low wages to introduce it on a large scale. In most first world countries, such competence is missing, or deemed to expensive. Asian countries like China, India and Bangladesh are the most suitable locations for production, which leads to very long lead times that are very difficult to overcome.

The reason behind the need for high degrees of human involvement in the industry is the technological barriers ruling out automation of a number of steps in the value chain. As technology advances, this will become less of an issue. However, for this to happen, increased collaboration between different actors may be necessary. The industry situation can currently be described as a waiting game, where actors are hesitant to take initiatives and try new things, opting to wait for competitors to break new ground.

7.5.3 Research Question 3

What opportunities could emerge for stakeholders of the custom-made fashion value chain?

In the context outlined in the examination of research question one and two, a number of opportunities for actors interested in large-scale production of custom-made apparel have been identified. Given the increased general interest in custom-made clothing, there seems to be a clear incentive for technology suppliers to invest in technology to enable a higher degree of automation within the industry, either in manufacturing or in information transfer throughout the value chain. As customization becomes more widespread, vast data can be collected regarding customer behaviour and preferences, which can provide valuable insights to be used also in bulk production.

Given that custom-made pieces of clothing can only be produced on demand, companies can overcome issues such as costly inventory and over-production by moving in that direction. Augmented reality could be an interesting area of technology to reduce much of the customer uncertainty associated with purchasing pieces of apparel before they are produced. By applying platform or modularization strategies and thereby postponing the CODP, mass customization can be achieved more efficiently.

As concepts and technologies from industry 4.0 are becoming more established, several challenges in the industry can be overcome. For example, the ever-increasing connectivity of production units around the globe allows for fully integrated and seamless communication demanding less human interaction and error. Putting an end to over-production and frequent return shipments will enhance firm profitability and to a considerable extent decrease the environmental impact of the industry.

8 Conclusion

This final chapter of the thesis highlights key findings and summarizes the project as whole. It includes identified challenges, business attractiveness and opportunities of industrial custom-made apparel.

The purpose of this thesis has been to analyze challenges and opportunities in industrializing manufacturing of custom-made fashion. As described in the introductory chapter, industry reports indicate that future fashion market express a need for custom-made apparel. This can be explained by customers showing an increasing interest in customization as well as concerns regarding the environmental impact and the profitability of the industry. With fashion being one of the most polluting industries worldwide, and customers showing an increasing interest in sustainable products, there is good reason for many players in the industry to reevaluate their practices and offerings. The recent trend of fast fashion means actors rapidly demand enormous batches based on hasty and inaccurate forecasts, often leading to over-production and undesirable working conditions in low-wage countries. An increasing share of apparel is also being bought online, where high return frequencies are causing damage both environmentally and to firm profitability.

It is thus clear that there are incentives for fashion brand owners and manufacturers to achieve large-scale production of custom-made apparel. However, the pathway there is obstructed by several factors, as explained unisonally by industry reports and professionals interviewed during the collection of empirical data for this thesis. A main concern is the technological aspect of fashion production. Due to the unpredictable characteristics of fabric, automation is currently limited to a much higher degree than in other industries. An implication of this is a need for manual labour. The economies of scale that can be found in the industry can be attributed to activities like cutting stacked layers of same-sized garments simultaneously. Since this can not be done when dealing with unique garments, custom-made fashion requires even more human involvement. As of today, custom-made apparel is seen as a premium product where production with low-cost labor often located far from end consumer, it often implies in long lead lime because of the transportation issue. Moreover, since custom-made products by definition can not be produced before a customer has made an order, it significantly impacts on production lead time due to operational capabilities.

Brand owners and technology suppliers interviewed during the data collection phase of the project also expressed similar views regarding a hesitance to experiment with new procedures in the industry. They cited a widespread fear of jeopardizing a brand's status by introducing new technologies or offerings that are not well-received by customers, explaining that it could have devastating effects. Nonetheless, there is also a curiosity for new technologies and a consensus that custom-made fashion will only become more important in the future. However, the risks of venturing into uncharted territory are deemed too high. There is thus a waiting game in the industry, where actors prefer letting their peers do the experimenting while remaining idle, following suit only if the experiment has seemed successful. This practice is in sharp contrast to arguments made by Lehmann et al. (2018) that the unleashing of the potential of future technology requires collaboration between actors.

It can thus be concluded that there is an increasing demand for industrializing custom-made fashion production, but there are barriers that need to be overcome in order for brands and producers to meet this demand. Given the hesitance of incumbent firms to take initiative and collaborate, there seems to be ample opportunity for innovative actors to capture market shares. In addition to innovations enabling nearshoring and shorter lead times through higher degrees of automation in the industry, it is anticipated that technologies reducing customer uncertainty would be of interest as well. Likely, this will be provided by new industry entrants that will contribute with their expertise from other areas needed to digitize the industry. An example of such an area is augmented reality, which could let customers get a clearer perception of a garments fit before ordering it, thus expediting the journey to fully industrializing the production of custom-made apparel.

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A

Appendix 1

A.1 Interview question sheet

Questionnaire Compilation		
Area	Question	Clarifying Question
Intro Questions		
	What is your name? How long have you been in the firm? What is your role in the firm? What is included in your firm's business?	
Operational Questions		
	What roles take part in your value chain? How does the process of bulk manufacturing look like?	
		How does the design and development look like? What materials are you using? How does the manufacturing look like? How is internal- and external logistic organized? What is the role of retail for your operations? Do you have an end-use sustainability program? If yes, how does that work?

Table A.1: Interview questions (1/2)

Questionnaire Compilation		
Area	Question	Clarifying Question
Operational Questions		
	How does the process of custom-made differ from bulk production?	
	How are you working with custom-made apparel today?	
	How are you working with made-to-measure today?	
	What challenges are implied by custom-made?	
	How do you work with your suppliers?	
Market information		
	Do you experience any difference in buying behavior between channels?	
	Who buys custom-made products?	
	What is the required delivery time for custom-made apparel?	
	How important is quality for customers buying custom made?	
	How important is price for customers buying custom made?	
	How important is CSR for customers buying custom made?	
	How do you experience market interest for custom made products?	
	How do you work to improve customer experience?	
CSR		
	How do you piroritize CSR?	
	What CSR investments are you pursuing?	

Table A.2: Interview questions (2/2)