AUTOMATED TECHNOLOGIES AS A SUBSTITUTE FOR CLASSIC OUTSOURCING IN THE
GARMENT MANUFACTURING INDUSTRY
AUTOMATED TECHNOLOGIES AS A SUBSTITUTE FOR CLASSIC OUTSOURCING IN THE GARMENT MANUFACTURING INDUSTRY
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Submission date: 19. June 2017
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Date: 19. June 2017

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Signature
ABSTRACT

Since the beginning of outsourcing in the fashion industry, companies have been seeking for ideal sourcing destinations. This practice brought along ethical and environmental issues while consumers have become increasingly demanding over time. The purpose of this thesis is to investigate the question to what extent automated technologies could present a solution and become an attractive substitute for classic outsourcing models in garment manufacturing. Therefore, the results of the thesis are based on primary research of five executed interviews with industry experts from an outsourcing and automation background. Additionally profound field research was conducted at the Adidas pop-up "Storefactory" in Berlin to analyse latest automated manufacturing trends. On this foundation, research showed that traditional outsourcing cannot yet completely substitute traditional outsourcing, but can rather be seen as a supplement or complement to achieve effective and reliable production at the current state. The implementation will cause influential changes, where especially developing countries have to watch out to not get outplayed by technological advancements.
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<th>Description</th>
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<tbody>
<tr>
<td>ASEAN</td>
<td>Asian Association of Southeast Asian Nations</td>
</tr>
<tr>
<td>ASM</td>
<td>Automated Sewing Machines</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
</tr>
<tr>
<td>CAM</td>
<td>Computer Aided Manufacturing</td>
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<tr>
<td>CNC</td>
<td>Computerized Numerical Control</td>
</tr>
<tr>
<td>CNY</td>
<td>Chinese Yuan (¥)</td>
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<tr>
<td>EUR</td>
<td>Euro (€)</td>
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<tr>
<td>FDI</td>
<td>Foreign Direct Investment</td>
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<tr>
<td>FOB</td>
<td>Free On Board</td>
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<tr>
<td>FTA</td>
<td>Free Trade Agreements</td>
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<tr>
<td>ILO</td>
<td>International Labour Organization</td>
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<tr>
<td>LAC</td>
<td>Labour Advisory Organization</td>
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<tr>
<td>MFA</td>
<td>Multi Fibre Agreement</td>
</tr>
<tr>
<td>Mn</td>
<td>Million</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research &amp; Development</td>
</tr>
<tr>
<td>ROI</td>
<td>Return On Investment</td>
</tr>
<tr>
<td>SAM</td>
<td>Standard Allowed Minute</td>
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<tr>
<td>SKU</td>
<td>Stock Keeping Unit</td>
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<tr>
<td>TPP</td>
<td>Trans-Pacific Partnership</td>
</tr>
<tr>
<td>USD</td>
<td>United States Dollar ($)</td>
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<tr>
<td>VND</td>
<td>Vietnamese Dong (₫)</td>
</tr>
<tr>
<td>WTO</td>
<td>World Trade Organization</td>
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<tr>
<td>3D</td>
<td>3 Dimensional</td>
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INTRODUCTION
1 INTRODUCTION

1.1 RATIONALE OF WORK

With increasing globalisation, the textile and apparel inland production delocalized to cheaper manufacturing countries in the past. Until today, the apparel manufacturing remains a resource-intensive industry with high labour costs. As traditional outsourcing countries start developing further and personal income grows, production often moves on to even lower-waged geographical regions. As an example, the dominant pattern was relocating production from China to Bangladesh, but now focus has shifted and even more cost competitive countries like Vietnam, the Philippines, or in Africa appear on the surface. (Berg, A., 2013)

Companies are constantly looking for new sourcing alternatives. Consequently, they are faced with the decision whether increasing the current suppliers’ productivity or emigrating to cheaper and faster production countries will be enough for a sustainable future. (Berg, A., Hedrich S., 2014)

In the textile and apparel industry, rising costs, compliance challenges, a lack of sustainability in safety, environmental, and overproduction measures are just a few issues the industry needs to tackle whereas speed and flexibility is becoming increasingly important for retailers. However, for ideal sourcing, companies have to balance price, quality, capacity, speed and risk. (Berg, A., Hedrich, S., 2014)

As automation is already established to a high degree in other industries like the automotive sector - the question arises how far the fashion industry has come in terms of automated production.

In the past, occurring problems for automation was the diversified material behaviour. According to the fabric components, it stretches differently and deforms easily in comparison to hard materials. Hence, rotating fabrics or accurately lining up seams belonged to one of its drawbacks (Reddy, K., 2015). The apparel manufacturing faces a transformation as many fashion companies innovate and test new technologies. In the footwear sector, Adidas one of the first, realised “re-shoring” by its automated production called Speedfactory and is now able to label its shoes ‘Made in Germany’ (Adidas, 2015). Various articles about ‘sewbots’, sewing robots, are appearing on the surface now, which will soon open up new doors and vanquish the difficult part of making automation in the fashion industry possible. With this in mind, big players in the industry should be aware for future planning.

1.2 RESEARCH PROPOSAL

As fashion companies are seeking for new sourcing alternatives in this complex environment, the question persists; to what extent automated robots could present the solution and become a more attractive substitute for classic outsourcing in garment manufacturing?
The main goal of this thesis is to examine classic outsourcing versus new automated technologies, and reflect on its current progresses. Considering that the future of manufacturing is opening up new horizons while at the same time new challenges arise.

1.3 STRUCTURE PROPOSAL
To answer the main question, sub-questions are constructed to get a sourcing insight for the future of manufacturing and provide the structure of this thesis.

1. What is the current state of the traditional outsourcing market?
2. What factors will influence manufacturing in the near future (next 10 years)?
3. What are the prospects for automated manufacturing technologies in garment manufacturing?

The first sub-question observes the current outsourcing market in the fashion industry. It is planned to look at its background, strength and weaknesses to discover if offshoring manufacturing is still profitable. To ascertain in what direction the industry is heading in terms of production, the second sub-question is dealing with influential outsourcing factors in the next ten years. Regarding the advancement of automated technologies, automation possibilities are perused in the knitting\(^1\) and sewing\(^2\) area. Part four provides the final comparison of classic outsourcing versus automation, according to its sourcing aspects speed, quality, capacity, risk, sustainability, people, and costs. Last but not least, a conclusion will be drawn to what extent automation is or will be an alternative for traditional outsourcing.

1.4 KEY METHODOLOGY
For this thesis, a combination of qualitative research and quantitative examples is used. First, qualitative secondary research is conducted across a variety of sources like academic literature, reports, studies, and digital media articles as well as film material to gain a profound understanding of the relevance of the topic and its sub-questions. By doing that, a common ground for discussion is established with, but not limited to, classic textbook definitions.

Second, to support the mainly qualitative argumentation throughout the thesis, field research is made and interviewees with an outsourcing and automation background give further insights. This constitutes the primary research part.

For more in-depth analysis, quantitative examples are used where applicable and where numerical data is available from public sources. Some further data points are provided by the aforementioned interviewees. These examples are considered representative and serve as measurement tools for further

---

1 Knitting definition: Knitting is a construction process of a fabric by the intermeshing of loops (Eberle, H., et al., 2013).
2 Sewing refers to goods assembled by sewing machine operations, which can include cut&sew knit pieces.
comparison between classic outsourcing and automation in terms of price, quantity, time, and labour attributes.

1.5 CORE LIMITATIONS

For this thesis, most applicable information about outsourcing and automation in the apparel production is used to make reasonable assumptions when necessary. Withal, limitations occur. One of my main limitations was to find the right interview partners, who are willing to provide me detailed information about the novelties in the industry. The difficulty consists in acquiring proprietary information, which may not be public. Second, for calculations and estimations, pretensions are made based on data found. Third, my ethnographic research is limited in outsourced countries such as the ASEAN region to observe and interview locally on the current situation and possible trends. This research on these countries is conducted from secondary data. As this topic also brings up an ethical problem, namely the effect on local workforce due to increasing automation, it will be briefly discussed. However, the main focus of this research lies on the future of apparel manufacturing and its progress in automation.
2 CLASSIC OUTSOURCING

Chapter two provides an insight into classic outsourcing starting with a definition and subsequently explaining the pivotal make-or-buy decision. Additionally, the second chapter illustrates the main outsourcing drivers for fashion companies and examines production types. It closes by giving an overview of the current sourcing landscape.

2.1 DEFINING OUTSOURCING

Before defining outsourcing, the meaning of sourcing has to be elucidated. Sourcing stands for externally obtaining goods and services. "Global sourcing" presents a procurement strategy with the aim to profit from global (manufacturing) efficiencies and can be synonymously used with "global outsourcing" as described by Robbin S. and Coulter R. (2012). (cf. Wikipedia online) Global outsourcing provides managers the opportunity for minimal upfront investment, especially when entering the international market, and is therefore a common strategy. (Robbins, S., Coulter, R., 2012)

According to Lysons K. and Farrington B. outsourcing is defined as “a management strategy by which major non-core functions are transferred to specialists, efficient, external providers”. An essential role when outsourcing plays the “make-or-buy decision” and the business relation between buyer and contractor. It should be noted that these outsourcing partnerships can often be disparately and should therefore rather be described by the term “co-sourcing”. (Lysons, K., Farrington, B., 2012)

An important aspect of outsourcing is its cost saving benefits if managed effectively. Instead of hiring a full-time employee, it is more cost efficient in many cases for companies to cede certain functions to third party vendors and only pay for its provided services or products. Most common areas for outsourcing include but are not limited to manufacturing, customer services, payroll and human resource services. (Investopia online) The lower overall costs, the more of a competitive advantage for the outsourcing company can be reached (Robbins, S., Coulter, R., 2012).

In the past, outsourced functions were often executed within a company and by its own employees (Investopia online). Yet, with emerging globalisation, outsourcing has become a more popular practice. This particularly holds in the fashion industry, where outsourcing targets especially manufacturing processes and moves them offshore due to low labour costs and different skill sets overseas. (Belcher, L., n.d.)

To summarize, outsourcing is defined as a business decision, when assigning subordinated work functions to an expert in order to save costs and sustain its previous quality. When speaking of outsourcing in the fashion industry, it is mostly applied for manufacturing, and refers to global outsourcing.
As demonstrated, this important strategy is primarily based on quality and financial aspects, which will be elaborated in part 2.3 (Investopia online). Considering these factors, outsourcing starts with the make-or-buy decision.

2.2 THE MAKE-OR-BUY DECISION

When starting a business, a "make-or-buy decision" (also "outsourcing decision") has to be made. Companies need to ask whether it is reasonable to buy from external entities and thus outsource certain parts of their value chain or keep all processes around a product or service in house. In the decision process, two factors, namely on costs and capacities have to be considered. Applying support questions such as 'is it more cost efficient to make or buy?' and 'do we have the production capacity?' can offer guidance on making this key-decision, which is often the basis to maintain a company's competitive advantage (Lysons, K., Farrington, B., 2012).

In general, considerations about quantitative and qualitative components of outsourcing play a role (Lysons, K., Farrington, B., 2012). On the quantitative side, for examination of profitability of outsourcing, margin- and break-even-calculations are necessary. Especially in the fashion industry, the quantity thresholds for a company to produce on its own are often too high and therefore investment in machinery not economic. Buying the exact amount from external sources is an obvious alternative and also minimizes the risk of inventory overhang. With increasing negotiation power of purchasers, delivery dates can be determined and no organization of temporary storage is required.

A qualitative reason for buying is risk sharing. Manufacturers are specialists in their field, providing expertise, professional machinery, and experienced partners. In cooperation, this leads to sharing of financial risk between buyer and maker. (Lysons, K., Farrington, B., 2012)

To fully understand the context of outsourcing in the fashion industry, the subsequent part provides the main drivers of outsourcing for fashion companies as a means to stay profitable and competitive.

2.3 MAIN DRIVERS OF APPAREL OUTSOURCING

Overall, the main reason for outsourcing is a strive for revenue increase. Lysons K. and Farrington B. (2012) propose a framework of outsourcing drivers. The following presents an application to the fashion industry. In principal, costs, quality, finance, and a more precise focus on a company’s core business are crucial consideration factors.

Costs

By outsourcing, costs can be diminished in land, material, service and labour (Nicy, L., 2016). With the aid of outsourcing, the most labour intensive step in apparel production can be reduced in costs and
consequently companies are able to enhance their competitive advantage. Especially with the rise of ‘fast fashion’, the cost pressure has increased and replaceability is a bigger threat than ever before. (See Appendix A)

Quality
A shortage of qualified garment workers in industrialized countries is the reason for deficient in-house capacity. In 1990, the United States still employed one million garment workers. As of data from February 2016, only 123,000 are left. (LA Times, 2016)
Due to the high wages in developed countries, outsourcing to developing countries offers a solution offering an abundant, young workforce while providing the quality needed. For a high performance level, commitments are given by contracted suppliers. When handing production to a supplier, it must be considered that quality standards differ according to varying skills levels across countries. (Lysons, K., Farrington, B., 2012)

Core business
Over the last years, research, design, marketing, and sales, became skill competences and gained more significance for fashion businesses (Gereffi, G., 2016). The activity of garment production drifted into a more subordinate operation, which lead to outsourcing and thus freed up time for the core business. (cf. Lysons, K., Farrington, B., 2012)

Finance
A company’s financial budget is limited and must be carefully thought out for investment. Key activities stand in focus as outsourcing is normally considered a move for the long-term. Offshoring a non-core-activity like production reduces in-house personnel costs. (Lysons, K., Farrington, B., 2012) In many cases, it is profitable for companies to simply pay for its provided end product. (Investopedia online)

2.4 TYPES OF PRODUCTION FOR OUTSOURCING
Outsourcing production creates additional operational complexity with many operational steps held in several countries. The textile and clothing industry can be broken down into two kinds of production. The price-quality ratio plays a pivotal role for outsourcing. Thinking of production of fast fashion brands with 52 collections a year differs from high-end fashion brands presenting two collections each year (Morgen, A., 2015).
The “High-end” or “High value” production relies on advanced technologies and skilled workers. In comparison, the “low cost” production is focused on low-cost labour and therefore also known for its often poor working conditions (ILO, 2014).
In general, implementation of technology is important for both types of production though - at all levels of the supply chain to improve performance. This is a necessity based on changing consumer needs and environmental issues. (Chang, J., et al., 2016)

2.5 SOURCING LANDSCAPE OVERVIEW

Choosing an appropriate outsourcing destination depends on each company's individual business model and its driving factors of price, quality, capacity, speed, and risk. An equal synergy of those factors is the basis for an ideal sourcing strategy confirms consultancy firm McKinsey. (Berg, A., Hedrich, S., 2014)

Picking the right outsourcing country comes down to differentiating between each country's varying comparative advantage. The following paragraph provides an overview and comparison of two major outsourcing countries.

While wages in conventional sourcing countries like China, Cambodia, and Vietnam are on the rise, other countries like Bangladesh pose a risk due to its poor working conditions and safety issues (Chang, J., et al., 2016). In a recent incident, 112 lives were taken at Tazeen Fashions when a fire broke out. Only a few days later, on the 24th April 2013, news about the Rana Plaza tragedy when 1,136 garment workers were killed in a factory collapse, has risen additional awareness about the state of factory safety. (ILO, 2016)

Yet, Bangladesh remains a popular sourcing destination, especially for fast-fashion companies, due to its low cost level and high production capacity. Wolfgang Uchatius describes in his article that one company in Bangladesh produces up to 125,000 T-shirts a day (2010). Half of it is for the fast-fashion giant H&M. This allows companies to push down prices and selling products like a simple T-shirt for less than 5 EUR (Berg, A., et al., 2012; Uchatius, W., 2010).

Looking at Portugal, as an example for the European consumer market, and comparing it with Bangladesh, the country allows lower order quantities and shows higher productivity, better quality products and safety guarantee, as well as shorter lead-times. Sara Tremblay, Product Developer for Karl Lagerfeld, exemplifies the capacity of a Portuguese T-shirt factory, which is able to produce 20,000-30,000 T-shirts plus per month (Tremblay, S., 2017). While “Portugal is more flexible realising a design within only 6 up to 8 weeks, with the assumption we have the fabric available of course. China, on the other hand, takes 6 months from development to final delivery.”(Tremblay, S., 2017). Nevertheless, labour costs are vastly distinct due to higher qualified labour. While a worker in a low-income economy like Bangladesh has earned 68 USD a month since 2015, Portuguese employees received a mid-income of 568,50 USD during the same time. (Cowgill, M., et al., 2015; Fair Wear Foundation online)

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3 In Asia, Bangladesh’s production capacity counts to the leaders with 5,000 factories and 3.6 million workers employed (Berg, A., et al., 2012)
The following figure presents an overview of monthly minimum labour wages of the top 20 exporting apparel countries in 2015. It clearly shows the labour cost differences between these countries of up to a factor of 10 between Sri Lanka (lowest) and Turkey (highest).

![Monthly Minimum Wages for the Top 20 Apparel-Exporting Middle and Low Income Countries](image)

**Figure 2.5-1: Monthly Minimum Wages for the Top 20 Apparel-Exporting Middle and Low Income Countries, in USD as of 1 January 2015 (Lowest and Highest Relevant Rate Applicable to Unskilled Workers)**

*Source: Cowgill, M., et al., 2015*

In general, apparel manufacturing economies in ASEAN have a comparative advantage providing a low cost and high capacity environment. "Low productivity, rising labour costs, and increasing labour disputes" (Chang, J., et al., 2016) are some of its current major weaknesses. (cf. Chang, J., et al., 2016) Mid-level income countries like Portugal (not included in figure), Turkey, or Morocco on the other hand can score with its high productivity, high quality products, and speed to market when speaking of the European consumer market (Cowgill, et al., 2015).

For a better visualization and more detailed insights into what smart outsourcing can achieve, please see the example of a representative simple white T-shirt in Appendix B.

## 2.6 CONCLUSION

To conclude, the outsourcing strategy, for fashion companies, especially to developing countries in Asia, can be a cost efficient method for companies. Outsourcing can result in a tremendous reduction in costs. Companies with large orders can profit from the suppliers’ economies of scale. This requires some sort of stability in demand. Hence, flexibility for short-term consumer demands, i.e. trend or quality requirement accommodations, as is the case with low quantity fashion items, might suffer due to the distance to production locations. This directly reveals why the classic outsourcing model cannot be applied to every product and be used by every company. There
is no “one model fits all”. Classic outsourcing has transformed over the years, but companies still continue to face difficult challenges they need to overcome when outsourcing.
TRANSFORMATION OF CLASSIC OUTSOURCING
3 TRANSFORMATION OF CLASSIC OUTSOURCING

This chapter examines threats of outsourcing. It analyses complexity of supply chain that outsourcing has brought along and looks at the specific reasoning of companies that use outsourcing. Finally, a case study on China shows the fast-changing transformation of an outsourcing country and its consequent shift in focus.

3.1 THREATS TO CLASSIC OUTSOURCING

Some of the main threats to classic outsourcing come from the inherent complexity in the process of creating and maintaining a smooth and functioning supply chain. The following parts identify these threats and break down how each of them influences the classic model.

3.1.1 DRIVERS OF SUPPLY CHAIN COMPLEXITY

In general, one of the main challenges in outsourcing is operational complexity when conducting international business. Coordinating production in the fashion industry requires strict planning. When outsourcing production, working across different time zones, language barriers, and cultural differences can pose a threat to smooth working processes. Further challenges are maintaining required lead-times and the unfamiliarity with local work environments. (cf. Nicy, L., 2016)

Evermore laborious compliance matters, unpredictable currency fluctuations, increasingly influential and highly demanding consumers, keeping a trustworthy relationship with overseas business partners, and environmental and ethical issues are some of these risk factors. (Bird, J., 2016)

Certainly one of the major issues lies in the relationships with the company’s contracted business suppliers. The control of an entire process is ceded to an overseas supplier, which means creating a high level of dependency for the outsourcing company. Often occurring problems with external vendors are a lack in flexibility, quality satisfaction, unexpectedly arising extra costs and a required long-term commitment. To diminish these risks, mutual respect and good communication with the supplier is needed. (Lysons, K., Farrington, B., 2012)

Progarment, a Dutch factory-owning company acknowledged that working with external suppliers, the assurance of flexibility, business stability, and quality often gets lost on the way, which hurts the trust in the supplier’s reliability. In 2001, when the business was just getting started, the company’s actual intention was to buy and resell Hong Kongese fabrics. The above mentioned reasons were enough for Progarment to take over the manufacturing process. (ProGarment online)

Nowadays, companies need to be aware of business practices of suppliers and subcontractors. “Organisations are increasingly being held responsible for the actions of their suppliers”, says French
Caldwell. “You can no longer claim to be unaware if your supplier breaches regulations on product specification or workplace safety.” (Bird, J., 2016)

3.1.2 CHANGES IN STANDARD OUTSOURCING DRIVERS
Outsourcing, the chase for cheap production opportunities in low-cost economies, which started in the 1960s, continues to be a main part of the strategy of many apparel companies. With increased competitiveness among brands and retailers, main reasons for offshoring and relocation of manufacturing to external companies included trade benefits supported by favourable trade agreements and government policies, cheap labour, and a supportive exchange rate (Chang, J., et al., 2016). However, most of these initially positive factors can turn around over time and make production in a country less attractive.

Rising Wages
The most crucial factor for relocating in garment manufacturing as a labour intensive industry has been high labour costs in the country of production. If, for certain reasons, wages start going up, this crucial factor might become obsolete. The reasons for local wage increases are diverse and may be due to protests by the workers as occurred in Cambodia, through governmental interventions like in Indonesia, or other economical influences. (See Appendix C)

Currency Appreciation
A favourable exchange rate can further make a point for the profitability of relocating. However, if tables turn and the currency starts appreciating for a variety of reasons, the business model shows its vulnerability with exposure to foreign currency cash flows. A good example for this is when American companies relocated manufacturing to China. (See Appendix C)

Trade Agreements
Beneficial trade agreements may also influence the choice of production country. The effect on savings can impact a company’s competitive advantage enormously. This makes it harder for countries outside the trade agreements to compete on the same consumer end price level. Previous examples show, that trade agreements are not set in stone and can change over time. (See Appendix C)

3.2 CASE STUDY: CHINA’S TRANSFORMATION OF AN OUTSOURCING COUNTRY
China belongs to one of many model examples as it underwent significant economic growth in the past and has developed from “world factory to innovative powerhouse” (Sarta, D., 2016) This case study presents a snapshot on China, as it is one of the most influential countries on the fashion industry.

China’s comparative advantage remains in its fully vertical supply chain due to its rich material provision and its strong manufacturing history, which resulted in prosperity. However, what used to be the reasons
for becoming a major outsourcing provider are not completely unique anymore with other countries catching up and becoming more attractive. Now, China is known for its high productivity and is focusing on investments, specific training and a lead-time shortage to maintain its leading position. (Chang, J., et al., 2016)

For years, China’s competitiveness was its low labour costs. The boom of the world factory brought improvements in infrastructure and a flourishing middle class with greater spending power. This, in return, resulted in a shortage of skilled workers and seamstresses. (Chang, J., et al., 2016) The trend for the next ten years is to migrate to cities, away from located factories at the countryside. “Look, we’re good for the next ten years, and then there’s no talent. In eleventh year there’s no one here”, said Reddy. (cf. Postrel, V., 2016)

**China’s Planned Revival**

Even though China remains at the top of fashion manufacturing, China fears that manufacturers get outpriced and replaced by competitors in cheaper developing countries. China’s economic plan is to promote automation in the manufacturing fields. Subsidies, which amount to several billions CNY, are therefore provided by the local government to companies to invest in robotic automation. (Manjoo, 2017)

For now, China belongs to the frontrunners in robotic investment (Reddy, K., 2016). In 2014, China purchased 25% of the world’s robots with the tendency increasing its part each year. After all, large investments in modern sewbots enable China to maintain its leading manufacturing position. (Chang, J., et al., 2016)

Companies in developing countries are often in no position to make these investments as of yet, whereas Chinese companies continue to purchase and use automated technologies (Chang, J., et al., 2016). (See Appendix D) China hopes to remain an attractive outsourcing and production location by investing in the future and thus being able to compete with other countries despite the changes to its production environment. This clearly reveals that the classic outsourcing model is in the process of alteration, which influences companies making use of outsourcing as well as the ones providing goods and services to them.
INFLUENTIAL FACTORS IN GARMENT MANUFACTURING
4 INFLUENTIAL FACTORS IN GARMENT MANUFACTURING

Technology and restlessness of consumers influence manufacturing practice. Therefore, chapter four examines arising trends and its impact on the apparel manufacturing sector by looking at technology advancements, the modification of consumer behaviour, and the resulting trend proximity sourcing.

4.1 TECHNOLOGY ADVANCEMENTS & INDUSTRY 4.0

3D presentation technologies such as 3D printing and virtual reality programmes, automated cutting machines, sewbots, as well as the Internet of things and cutting-edge analytics are progresses, which are becoming more important. Some of these technologies are almost indispensable, as these inventions will promise long-term growth and a greener future. With (automatic) digital big data transfer, a reduction in manufacturing time and required labour is predicted. All digital systems can further reduce or even completely eliminate waste in some form.

Of these technological advancements, all can be interconnected and process steps (partly) automated with the rise of Industry 4.0, which will be described in the next part.

Industry 4.0, also called the “Smart Factory” is seen as the fourth Industrial Revolution, after the innovation of mechanization by water and power steam in the first era around 300 years ago, electricity and mass-production invention in the second, and emerging computer systems and automation in the third (Nicy, L., 2016; Wikipedia online).

Industry 4.0 developed out of the high-tech strategy initiative of the German federal government. It is powered by the Internet and stands for the digitalisation of the industry by connecting, communicating machines, warehouse systems and operating resources with each other via cloud computing. The smart factory makes it possible for companies to fulfil individual demands and is geared to complete big, as well as small orders, which was not possible with mass-production in the past. (BMBF online)

Before Industry 4.0, resource procurement was pivotally managed, but now orders can be automatically placed over the Internet and directed to the external supplier. The decentralised managing system therefore enables to speed up the process and hence makes manufacturing more flexible, faster, and more efficient. Computerized manufacturing is thus characterized by transparency for consumers and affiliates of every step in the supply chain. (BMBF online)

The fashion industry acts a part of the Industry 4.0. Sporting goods giant Adidas is one of its pioneers. Its so-called Speedfactory project was incorporated to the national programme “Automatic for Industry 4.0” under sponsorship by the Federal Republic of Germany with the aim to form the “Future of Manufacturing”. With its three years research project, which started in October 2013, Speedfactory includes cutting-edge technology such as “3D printing, computerized knitting, and robotic cutting” (Tess, 2017) and is its first automated shoe factory in Ansbach, Germany. By now it has already proven its
success, which in return led to the decision of an additional planned opening of a US-based plant in Atlanta in 2017. (cf. Adidas, 2013)

Gerd Manz, Vice President of Technology innovation, of Adidas explains that “[...] each consumer can locally get what they want, when they want it, faster than ever.” (Oconnell, E., 2015)

Industry 4.0 is also another step towards more sustainable production. However, it is not the only trend establishing sustainable manufacturing practices. The next paragraph dives deeper into long-term sustainability implementation.

4.2 SUSTAINABLE MANUFACTURING IMPLEMENTATIONS

With increasing awareness of consumers and companies about ethical and environmental issues, attempts have been made in sustainable manufacturing practice. The trend of growing corporate responsibility results in safer and greener working environments.

More sustainable production techniques are implemented to reduce water, power, and electricity use, as well as minimizing waste, e.g. by using biodegradable materials. These greener manufacturing inventions will challenge producers to enhance efficiency and related compliance matters. (Chang, J., et al., 2016)

The following three examples present non-pollution techniques with no consumption waste, material reuse of waste, and zero waste manufacturing methods to illustrate sustainable innovations in apparel manufacturing.

4.2.1 NO POLLUTION AND CONSUMPTION WASTE

Vat and cationic dying are commonly used techniques in the apparel industry. It is known for its abundant use of water, polluting chemicals usage, and bleaching coloration after time. With the invention of AirDye Technology, a sustainable manufacturing process was created, which dyes without the abundant use and pollution of water, but also saves energy and therefore ultimately costs. (New Cloth Market, 2009)

4.2.2 WASTE REUSE

In 2016, Adidas initiated the Parsley project, an attempt of creative waste workmanship, which recycled plastic recovered from the ocean to a yarn and created football jerseys and shoes out of it (Adidas Parley, 2016). 7,000 Parsley shoes came on the market and were sold out in minutes. (GQ Australia, 2017)

4.2.3 ZERO WASTE

In 2012, Nike introduced a computer controlled knitted innovation for its Flyknit running shoes, which allows to manufacture with “zero waste”, for the first time. The shoes are manufactured on a STOLL knitting machine by a single yarn with no cut outs and thus no waste produced (Tannenbaum, P., 2015).

With popularisation, the advantage of this knit innovation is to save overhead and labour costs, but most
importantly reduce waste. In comparison to other Nike shoes, Nike’s Flyknit shoes reduce the waste total by 80%. (cf. Chang, J., et al., 2016)

Next to plain technology advancements, consumer demands are triggers for more sustainable manufacturing practices due to more consciousness about unethical working conditions and environmental issues in the fashion industry. This introduces a shift in consumer behaviour, which has to be considered by companies in order to stay successful.

4.3 MODIFICATION OF CONSUMER BEHAVIOUR

Today consumers are presented with a plethora of products and services. Following paragraph defines today’s most influential generation, its expectations, and demands.

4.3.1 THE INFLUENCE OF GENERATION Y

Millennials are a main influential factor on the clothing industry. The ‘Generation Y’, born in the 80’s and 90’s, are the current force behind changing consumer behaviour as they currently capture approximately 40% of the global retail sales, a number increasing annually. (McGregor, L., 2016)

The hard part for companies is adjusting to the volatile demands, as this consumer group often does not know what it exactly wants. On one side, consumer research has discovered their appreciation for quality and sustainable products. For this generation, which grew up with the Internet revolution, not only online shopping will be the future, but also it still appreciates different alternatives such as physical stores and mobile shopping. It is noteworthy that the millennials have no acceptance for rising prices (low price elasticity). (McGregor, L., 2016)

One noticeable trend is the experience offer of personalised articles for the mass, which will most likely further enhance over the next upcoming years due to more advanced technology.

4.3.2 FROM MASS-PRODUCTION TO MASS-CUSTOMISATION

In the past, customisation was expensive and a status symbol. Through technological advancement, personalisation in products and services is more attainable and less expensive than ever before. (Fenech, C. and Perkins, B., 2015)

Customisation is in high demand, which brands like Nike ID, proved during the co-creation launch in 20094. Nike’s total revenue in the fiscal year 2009 was 19,176 USD (2016: 32,376 USD) with

4 Only available data found on NikeID revenue during co-creation launch in 2009. Most probably high skewed numbers due to the launch.
approximately 0.5% (100mn USD) revenue from its customisation NikeID products (Nike, 2015; Nike 2016).

Today, more and more retailers and brands have inquired and provide customisation for a variety of products. Not just brands like Adidas and Nike, but also high fashion brands like Burberry or Anya Hindmarch included online customisation to their business model for the consumer to personalise their individual design. Tailored products are very popular in customisation. SuitSupply is just one of many, who offer the function for men to ‘design your own’ shirt or complete suit (SuitSupply online). Suit Supply will most probably profit from this trend in the future based on more advanced technologies, namely the access to affordable 3D body scanners. (cf. Chang, J., et al., 2016)

3D body scanners are the new medium for upper and mid-range brands. Today, the cost for the end-customer is high, but in a decade, the process is expected to be optimized, more cost-effective and might even be used by large retailers like Wal-Mart (Chang, J., et al., 2016).

“Custom-made clothing is going to be a big thing. Consumers will be able to scan their own body at home and send a scan to their favourite brand and make custom clothing from it. This, I definitely see happening by 2030” Roger Lee, CEO, TAL Apparel Group (Just-style, 2014)

![Flow Chart for Mass-Customisation](image)

**Figure 4.3.2-1: Flow Chart for Mass-Customisation**
Source: Chang, J., et al., 2016

However, not only technology induces re-shoring. Tendentially more brands, retailers and manufacturers are coming back from countries they once outsourced to due to several advantages, which will be elucidated in the following.

### 4.4 PROXIMITY SOURCING

Lead time is a crucial factor in order to be able to react quickly to customers’ needs. Flexibility in design adaptability, quality improvements, and short time-to-market is what more and more fashion companies are seeking for. (ILO, 2014) Multiple McKinsey (one of the major strategy consulting firms) surveys point out the trend of “near-shoring” or so-called proximity sourcing for apparel players, especially mid-market (81%) and value player (53%), to shorten the lead time by relocating production closer to where the
market is. Re-shoring production closer to home often means Turkey or North Africa for European markets and Central and Latin America for the United States. (Berg, A., 2013)

Through globalisation and the widespread use of media and Internet, awareness of who actually made the clothes grew over the last years. Labelling your products "Made in [Europe]" may therefore be a good marketing and business tool to profit from. (FashionUnited, 2016)

Interviewee Progarment, a Dutch-owning manufacturing company with yearlong experience abroad, plans to set up a production facility in the Netherlands providing products with "good quality for a realistic and competitive price" (Smits, C., 2017). "Honest production" is what the company is aiming for by offering unemployed locals an occupation. Therefore, Progarment’s strategy is to re-shore easy producible garments like underwear, which is its main driver of turnover⁵. Another advantage of re-shoring is the ability to manufacture smaller quantities with no high minimum orders, which often occurs in Asia. Additionally, the step between manufacturing and delivery is minimized and results in a shorter lead time. (Smits, C., 2017) Progarment is not the first to venture the step of re-shoring. With a focus on the British market, many luxury brands like Burberry, and Victoria Beckham, but also mid-class brands like Fred Perry, and small start-ups like Justin Tabak, already produce in Great Britain. Over the last five years, the textile and clothing production industry in Britain increased 9% and forecasts say that until 2020, 20,000 more workplaces will be created. (FashionUnited, 2016)

Summing up the findings, advantages to produce close to home are, besides responsible production and speed-to-market, the possibility of higher flexibility by being involved in the production process and able to reduce travel costs. (FashionUnited, 2016; Smits, C., 2017) To keep up with consumer wishes, a simpler supply chain with shorter production lead-time is needed (Tess, 2017).

Automation in apparel manufacturing could enable simpler supply chains and help to deal with the challenges of the described trends. In the past, instead of automation, seeking for cheap workforce and cutting costs by outsourcing was the go-to solution to tackle some of the issues. (Nicy, L., 2016)

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⁵ Firstly, unemployed do mostly not have experience in sewing. Secondly, labor intensive garments and experienced seamstresses claim a higher salary. Thirdly, the productivity speed would be higher in Asia for labor intensive garments. (Smits, C., 2017)
The next part of this thesis investigates the current state of automation and whether it could be a potent alternative to classic outsourcing. Furthermore, it examines the idea what the consequences of this would be.
AUTOMATION IN GARMENT MANUFACTURING
5 AUTOMATION IN GARMENT MANUFACTURING

Chapter five examines the current state of automation in garment manufacturing, its benefits and limitations looking at knit and sewing production, as these two fabric or garment construction techniques are quite different in their process.

Automation in an industry can affect an individual business strategy. As previously analysed, fashion companies decide in most cases to buy from outside and therefore outsource (at least parts of) production. With an available automated technology, the make-or-buy decision may lean towards “making” instead, which in turn provides companies with the freedom and control over production.

Before applying the concept to automated knitting and sewing technologies, automation is generally defined. To also put automation in context, the following part gives an introduction to recent developments in the fashion industry and looks at the advancements in manufacturing processes.

5.1 DEFINING AUTOMATION

“Automation” is defined as an electronically self-controlled system, which works partially without or minimised human intervention (Dictionary online). According to Robbins, S. and Coulter R. (2012), automation is described as technology advancement when machines, such as programmed robots, take over job tasks of humans. Therefore automation can also be seen as robotization. Hence, it enables the replacement of human labour while at the same time machines can be programmed economically to achieve a level of low energy and material consumption. In order to reach quality improvements through automation, accuracy is the key for the system. (Wikipedia online)

5.2 AUTOMATION DEVELOPMENT

Next to the automotive and aeroplane industry, textiles production belongs to the most automated industries. In many cases, automation helped companies to revive their business. On the contrary, automation in garment manufacturing has not advanced to such a degree. The following part examines in which process steps automation can be used and highlights main difficulties in garment manufacturing.

5.2.1 CAD/CAM

Computer aided applications like CAD/CAM (computer aided design/computer aided manufacturing) systems are used from design to manufacturing and help to automate apparel production. CAD applications range “from design, pattern making, grading, marker production, to lay planning” (Eberle, H., et al., 2013). It enables companies to create new and alter existing styles with the help of a computerized system. (Chang, J., et al., 2016) So far, technology is able to virtually prototype by simulating fit and fabric
drape (Machtinger, S., n.d.). Thus, it realises shorter time-to-market, cost savings, and presents a greener approach of prototype creations (Chang, J., et al., 2016).

CAM applications, on the other hand, are specialised in “warehouse, cutting, sewing, pressing, finishing and dispatching” (Eberle, H., et al., 2013). The system can operate computer controlled machines such as large plotter machines, fully automated CNC (computerised numerical control) fabric-laying machines and fabric cutting machines, which help simplify the production processes. Results are reduction in waste and accuracy of cutted patterns for seamstresses. (Bilalis, D., 2000)

In industrialized countries, computer aided applications, are already widely distributed, whereas in ASEAN factories, these programs are integrated at a slow pace. The frontrunner in the ASEAN area is Vietnam, where CAD technology has been applied over the last 10 years, followed by Thailand and Indonesia. (Chang, J., et al., 2016)

### 5.2.2 AUTOMATED CUTTING MACHINES

CAM controlled automated cutting machines, for example, can lead to upgrades in quality, costs-savings and reduction of labour and waste (Bilalis, D., 2000). Automated cutting machines have become a widespread technology and beneficial for productivity increases based on speed advancements and minimized employment of labour. Before that, manual cutters cutting out fabric by hand were seen as high skilled employees. (Chang, J., et al., 2016)

According to ILO research, a foreign-owned apparel company in Vietnam revealed that with the invention one automated cutting machine could take the place of 15 manual workers. Now, one employee operates 3 up to 4 machines and monitors if they run smoothly. Estimations predict, after the short time period of 18 months, the investment’s break-even point is reached. (Chang, J., et al., 2016)

Marble Trading Co. factory joined the project “Smart Myanmar” and profited from its advice to restructure their cutting department by committing to automated cutting machines. Thet Su Zin Win, factory director, was marvelled by the outcome: “There is no longer re-cutting in the sewing department. It saved us approximately 3,600 USD a year: 65.4 per cent on material costs and 34.6 per cent on labour costs.” (Kyaw, K., 2016)

### 5.2.3 SEWING PRODUCTION

Sewing automation in garment manufacturing for high speed achievements, which eliminate the most labour intensive sewing step, already exists on the market for certain machine types with the ability of cam-controlled automatic. However, the placement of fabric and trim has to be done manually. (Eberle, H., et al., 2013) The previous mentioned CAM systems allow storing those computer controlled sewing
machine programs and invoking them when needed. Constant automated machine companions are for instance the buttonhole sewing machine, button sewing machine, and bar takers. (The Economist, 2015; Eberle, H., et al., 2013). Further CNC-controlled workstations are collar assembly, pocket makers, and patch pocket maker's workstations, which are often provided in “high-end” production facilities (Eberle, H., et al., 2013).

As seen in previous examples, only "single" workstations can be automated. The main difficulty, referring to woven or cut&sew knit pieces, to fully automate in the garment manufacturing process, presents the material handling process. The difficulty consists in the variety of fabric behaviour. Based on its components, it stretches, wrinkles, and deforms compared to hard materials, which keep their form. This is the main difference to other industries, which already automated their production to a high degree. Attempts to overcome these difficulties have been performed, however, unsuccessfully. Systems in the past used clamps to brace the fabric, which restricted particular sewing operations. (Reddy, K., 2016)

The next step in automation would be an innovation to combine automated sewing machines and fabric handling systems, which is at an early stage and will be examined in part 5.4.

5.2.4 KNITWEAR PRODUCTION

In comparison to woven garment manufacturing and its sewing process, knitwear production is already a step ahead and further automated. 3D knitting is a seamless technology, which makes it possible to knit an entire garment without any cut&sew assembly necessary (Powell, N., 2005). In 3D knitting, three types of seamless methods have to be differentiated, namely circular knitting seamless, warpknitting seamless, and flat knitting seamless. Each comes from a different machine manufacturer and is preferably used for certain purposes.

The focus in knit production in this thesis lies on computerized complete flatbed knitting machines offering versatility and which is one of the least labour intensive production assembly method so far. It enables the production of shaped garments with a variety in design and knit structures directly adjustable via CAD systems and is opening up new possibilities in mass-customisation (Powell, N., 2005).

Since its launch in 1995, complete garment knitting has increased in market share, based on higher productivity than earlier machine models. Today, up to 20-25% of clothes are produced on such industrial machines worldwide (Dezeen, 2015). Designer and brands such as Max Mara and Versace are just a small fraction, but also retailers such as Mark & Spencer and Oasis contribute to the share. With the extension of a finer knit rang, the popularity in particular in sportswear and casual wear has grown. (cf. Power, E., 2014; Shima Seiki online)
Most commonly used for this technology are Shima Seiki’s “Wholegarment®” or Stoll’s “Knit&Wear®” machines. Dependent on machine type, a wide array of product groups can be produced on a complete garment machine. (See Appendix E)

With the fourth industrial revolution taking place, new steps towards automation are made in mass-production and mass-customisation. By integrating the latest cutting-edge software developments for flat knitting seamless and introducing sewbots new possibilities arise, which will be examined in the subsequent part.

5.3 KNITTING AUTOMATION

Advancements in automatic 3D knitting are currently computerized flatbed machines, which are bringing mass-customisation to a new level. The latest software for flat knitting seamless succeeds to realise personalised items on demand. The hurdle of complex labour intensive and time-consuming programming in between production, which required even more time for different sizes and colour options, has been eluded (Arkko, T., 2013). Industry 4.0 supports the software and thus enables customisation on demand on an industrial scale. Preferential economy of scale production was tried to be achieved due to the long programming burden, which with more sophisticated and efficient programming capacities available lies in the past. (Unmade online)

5.3.1 CURRENT STATE

Automation in knitwear production has become a digital process, which has reached the point to allow consumers to be co-designers in the process, deciding on fit, design pattern and colour. “The reason [mass-customisation] hasn't happened before in knitwear is that the design tools that exist are very old fashioned, almost like 1980s, 1990s-style CAD,” Alun-Jones, founder of Unmade reveals (Dezeen, 2015).

Unmade, is a good practice example, which allows consumers to design their own individual knitwear online. The British company managed to developed a software, which manipulates industrial knitting machine with the possibility to produce customised “one offs to the same unit costs and speed as mass-production”. Once purchased online, the company’s order management systems converts individual data to a machine-aided knit file and is sent to the machine. (Unmade online)

Beginning this year, Adidas started a pilot project, with the same principle on customised knitwear, but tested local retail production on-demand. This concept enabled the consumer to jump into the role of the designer to personalise its sweater's design based on pattern motive and colour in store. With the integration of a body scanner, consumers could additional customise their product in size. All its created

6 Different sizes require individual grading. Likewise, the thickness of the same yarn may differ due to the dying process, which changes the outcome and therefore must be independently programmed. (Arkko, T., 2013)
information was saved on a QR code. Once scanned to the system, the information was sent to a STOLL Knit&Wear machine, which knits the self-designed and fitted sweater.

Both companies produce on flatbed knitting machines. However, while Adidas takes advantage of the 3D knitting technology, Unmade still assembles the panel knitted pieces by the labour intensive step of linking. (Stylebubble, 2016)

5.3.2 ANALYSIS OF ADIDAS STOREFACTORY

Based on the example of Adidas ‘Knit For You’ Storefactory in Berlin, sourcing aspects are analysed applied with regards to quality, capacity, speed, risk, people and sustainability.

Quality
Thanks to automation, the knit quality of the products shows more consistency due to machine-controlled yarn tension resulting in regular loop sizes (Powell, N., 2005). Human errors of labour intensive production operations such as knitting, sewing and linkage can thus be eliminated. Flatbed knitting machines offer versatile design possibilities. Even metal can be enmeshed. (Stoll Interview, 2017)

Capacity
One major advantage of automated technology is to be able to notionally produce non-stop. To calculate the maximal output, it must be considered that the STOLL CMS 830S Knit&Wear machine can be setup to knit three sweaters simultaneously with an outcome of 48-72 sweaters a day. On top of this, Adidas Storefactory invested in three knitting machines in total, which tops the capacity to a maximum quantity of 144-216 sweaters. (See Appendix F) This pilot project proves that it is possible to set up a factory in only a store space and manufacture to industrial scale. (cf. Adidas Field research, 2017)

Speed
Concerning the speed of production, the total lead-time can be drastically reduced. By moving production to the key destination market, based on this technology, the entire creation process can take place where the consumer is, namely in store. (Galileo, 2017)

![Figure 5.3.2-1: Process Timeline of Adidas Storefactory](source: Own representation (Adidas Field research, 2017; Adidas Interview, 2017))

After the design process, which takes around half an hour, the saved individual information is sent to the knitting machine. The machine knitting process takes 60 up to 90 minutes depending on the sweater’s design and size. Based on the Knit&Wear technology no extra workmanship like the costly linkage process after knitting is required, which results in reduction of production time. After knitting, only minor
manual adaptations are necessary. The final finishes include the washing and drying process, but also to
darn in all threads, attach the label, steam the sweater to shape and package it, which is prepared in
another 2.5 up to 3 hours. All in all, a personalized fitted and designed sweater is ready for pick up after
approximately 4 hours. (Adidas Field research, 2017; Adidas Interview, 2017)

Risk
Based on the Storefactory, inventory and its SKU can be kept at a low level. The risk of abundant
inventory can be thus prevented. Adidas tested this with its pre-designed sweaters in standard sizes,
which were produced in advance before each micro season started. Out of stock articles in a certain
colour and size, could be produced on demand without any problems. (Adidas Interview, 2017)

People
For the actual production process two employees are involved, one for knitting and the other one for the
sweater’s finishings (Adidas Interview, 2017). The knit technician is qualified for the software and the
maintenance of three knitting machines. After scanning the QR code and pressing two buttons the knitting
machine takes over. Once the pullover is knitted, another employee continues with the final finishes as
described above. (Galileo, 2017)

Sustainability
Zero waste is a major sustainable advantage of the seamless technology, which is comparable to 3D
printing. While cut&sew garments produce approximately a total fabric loss of 30% by cutting out the
patterns from a fabric, the same panel knitted piece requires 14% more material for the 1cm seam
allowance and linkage of the garment than a 3D knitted piece. (KNIT.melbourne online)

5.3.3 LIMITATIONS
Common limitations of complete garment machines still need attention despite the advancements. So far,
the realisation of mass-customisation on a seamless flatbed knitting machine is the most automated
stage in garment manufacturing. Still minor final finishes have to be done manually, which prevents the
fruition of an entirely automated factory.

In the case of “Knit for You”, Adidas used a STOLL CMS 830S Knit&Wear machine with a gauge\(^7\) range
sizing from E7.2 to E9.2 (Adidas Field research, 2017). Overall, the gauge availability from complete
garment knitting machines offers variability from 5 up to 21 gauges. Yet, the expensive machine prices
limit (which is elaborated in the next part) the offer on a marginal gauge range and knit structure. (cf. Stoll
online)

\(^7\) Gauge is “needles per inch” (Power, E, 2014)
Another limitation Knit&Wear machines present is its costly machine set up for different yarn gauges (Danchuk, M., 2016). This limitation can most likely not be prevented by the software. Adidas, for example, uses identical yarn types in various colours in the same sizes, for which the proprietary software is programmed, since even minor deviations in yarn sizes can result in an unpredictable outcome (Arkko, T., 2013; Stoll Interview, 2017).

Therefore, Adidas as well as Unmade use the same concept and propose standard designs to the consumer. In this case, the gauge, yarn size, a range of colours, the jacquard pattern (to achieve this prominent self-design pattern motives), and shape of the garment are defined by the company. This can be co-designed in fit alterations, the available colours, and design motives. For example, if a customer wanted a special knit pattern surface, such as a cable knit on the front of the sweater, in a colour outside the given range, the modern software would not be programmed accordingly. Therefore, design possibilities exist, but are not limitless due to time-consuming and complex programming of the software.

It is noticeable, that Adidas and Unmade both use merino wool\(^8\), a natural fibre with “elastic, flexible and durable yarn”(Powell, N., 2005) properties, recommended to bypass the general issue of complete garment machines in open, less elastic knitting at the cast-ons and -offs\(^9\), caused by the alternate needle selection. So far, the consumer cannot decide on individual yarn composition, since choosing a suitable yarn is difficult. (Powell, N., 2005)

When technical defects of the machine occur, such as slipping a stitch or knitting a front and back stitch together, the entire garment is not utilisable and rates as waste, which accounts to around 10-15% of cases (Arkko, T., 2013).

5.3.4 INVESTMENT COSTS AND POSSIBLE INVESTORS

The STOLL Knit&Wear machine 830S Adidas Storefactory uses, costs around 100.000 EUR (Galileo, 2017). For companies to invest in such a machine, a minimum sell out of at least 575 units must be calculated in order to profit from the investment.\(^{10}\) Yet, with rising competition and technology

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\(^{8}\) In general popular fibers for seamless garments are: natural fibers such as cotton (vegetable fibres), wool, cashmere, angora etc. (animal fibres) and man-made fibers such as Viscose (natural polymers), Acrylic, polyamide including Lycra or other elastomers (synthetic polymers) (Powell, N., 2005; Eberle H., et al., 2013)

\(^{9}\) Cast-on and cast off can be seen as clean edges. In a case of a sweatshirt cast-on and cast-off occur at cuffs and waistband (cast-on) or neckline (cast-off) for example.

\(^{10}\) The calculation is based on STOLL machine price of 100.000 EUR, plus 15.000 EUR for the software, and the Adidas sweater costs of 200 EUR (115.000 EUR / 200 EUR = 575 pieces) excluding costs of maintenance, service charge, and interest (Galileo, 2017; Stoll Interview, 2017). The calculation is a conservative estimation, while one can assume that the software developed for Adidas costs more.
advancement on the market, 3D knitting flatbed machines will become more affordable (Danchuk, M., 2016).

In the past, customers of the technology were primarily brands, with established Knit&Wear specialised factories in proximity. The fashion company Marccain, for example, as Interviewee Stoll reveals, is one of the technology’s main users among brands. (Stoll Interview, 2017)

Looking at investors of STOLL Knit&Wear machines by area, Asia is a big customer. However, in general, less Knit&Wear technology can be found in low income countries. (Stoll Interview, 2017) According to the knit consulting platform KNIT.melbourne (online), Italy, Spain, and France are its biggest users. This shows, that knit robotization has already been in proximity for the European market in the past. In greater detail, complete garment machines are commonly represented in specialised, “high-end” factories, which can cover large investments.

With the innovation of compatible software allowing the breakthrough of mass-customisation on whole garment machines, investments might become more interesting for brands with heavy R&D (research & development) budgets, who can also afford the purchase of one to three machines for their stores to serve its customisation business. (See Appendix H) Brands and retailers, particularly in the luxury market, are always seeking for latest technology advancements and innovative marketing chances, which would be a match with the idea to bring manufacturing home or even in store (Power, E., 2014).

5.4 SEWING AUTOMATION

Since the beginning of apparel manufacturing, human workforce was involved. With the introduction of sewing robots, the way business was done, mainly chasing after low-cost labour, will face changes.

Softwear Automation, is one of the very few tackling sewing automation in the textile and apparel industry for cut&sew pieces, which is able to bridge a big niche in mass-production and enables the simplification of complex supply chains (LaWell, M., 2017).

With Software Automation’s Sewbots™, Industry 4.0 can thus be entirely embraced in the garment manufacturing industry, gathering data about each process and making the entire supply chain transparent and reaching more efficiency (Simone, A., 2017).

The following paragraph examines carefully to what extent sewbots are integrated in the industry and for what to look out for.

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11 Sewbots™ is a listed trademark of Softwear Automation
5.4.1 CURRENT STATE
Since the end of 2016, LOWRY, a material handling technology and ASM (automated sewing machine) of Softwear Automation are able to cooperate without any human interaction (Chang, J., et al., 2016). Due to costs lowering in technology, and increasing processing power over time, automation has reached a point where it is able to meet market requirements (LaWell, M., 2016).

Solving technical problems, which seemed impossible in the past, has allowed Softwear Automation to develop robotised sewing worklines, called Sewbots. Softwear Automation says “we program all of the machinery ourselves using customer’s cut files - the pattern making files they use to mark their fabrics for cutting using industrial automated cutters.” (Simon, A., 2017) According to the customer’s needs, the machine’s catalogue can then be adjusted quickly for delivery by Softwear Automation’s engineers (Simon, A., 2017).

For now, the company’s main customers are based in the home goods sector. Yet, as Sewbots immediately suggests itself to expand into the garment manufacturing, the company has grasped the opportunity to tackle automation with its first shipment of a fully automated production T-shirt line to an Asian manufacturer in 2018. (Simon, A., 2017)

5.4.2 ANALYSIS OF SOFTWEAR AUTOMATION’S T-SHIRT PRODUCTION LINE
The following part analyses influential sourcing aspects on the example of Softwear Automation’s T-shirt production line.

Quality
Clamping and semi-automation attempts to fully automate are superseded by computer vision. Softwear Automation managed to manipulate the fabric behaviour, mastering the system to even out the fabric in case puckering occurs. (LaWell, M., 2017) On top of this, the Sewbot works with half-a-millimeter accuracy. Sewing a circle results in close-to-perfect results, which a seamstress nowhere near enough can achieve. (Postrel, V., 2016)

Capacity & Operators
In regards to capacity, CEO K.P. Reddy, promotes: “Our machines can run 24 hours straight - which is much longer than a traditional shift by a sewer[…]” (Chang, J., et al., 2016). With the launch of a fully automated production line for T-shirts in mid-2018, Interviewee Anastasia Simons reveals that it “will allow a single operator to produce one million shirts per year” (2017). The capacity of one Sewbots can already
beat the output of a Portuguese jersey manufacturer, who produces for Karl Lagerfeld, Hugo Boss, Inditex and Nike.¹² (Tremblay, S., 2017)

**Speed**

Sewbots make it possible to SEWLOCAL™ as Softwear Automation calls it. “Some brands will turn to manufacturing closer to their end consumer for trend pieces that are hard to forecast or for staple items that can be custom finished in a warehouse before shipping-- think hemming jeans”, explains Anastasia Simon (2017). Bringing production facilities back to the homeland, can cut lead times and its costs. Thus, consumer needs can be fulfilled in a time-to-market environment with speed production and fast delivery satisfaction. (Reddy, K., 2016)

**Risk**

Industry 4.0 enables to make the entire supply chain transparent by “collecting and communicating data about everything from defect rate to needle down time” (Simon, A., 2017). This eliminates the risk of unsolvable issues and time. Similar to the knit automation risk minimisation regarding high inventory, SEWLOCAL™ allows quick reaction and the ability to manufacture on-demand.

### 5.4.3 LIMITATIONS

Sewing robots sound promising for the future. The question only persists when Sewbots will gain acceptance and popularity on the garment manufacturing market. Therefore, the following timeline illustrates an insight into Softwear Automation’s milestones regarding the advancements and integration of Sewbots in apparel manufacturing.

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#### Figure 5.4.3-1: Rough Milestone Outline for Sewbots in Garment Manufacturing

Source: Own representation (Simone, A., 2017; Software Automation online)

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¹² Capacity of 360,000 T-shirts plus (of Portuguese manufacturer) versus 1,000,000 T-shirts (produced by one Sewbots) a year
Since the launch of LOWRY, Softwear Automation is continuously working on perfectioning its basic operations such as “pillow, edge sewing mats, towels etc.” (Simon, A., 2017), in order to succeed managing more complicated operations (Simon, A., 2017). Consequently, mass-customisation is at this state still a vision. Anastasia Simon, predicts that body scanners in store and custom-made garments, which was only recently realised in the knits area, can cooperate with Softwear Automation’s technology in the next 5-10 years (2017).

Meanwhile, the company is also working on the development of its capacity by broadening the fabric library and its handling system, as well as its operation array. By now, the company is able to work with a range of mid-weight woven and knit fabrics. The limitation persists “when it comes to silks and extremely lightweight synthetic fabrics” Interviewee Anastasia Simons (2017), reveals. CEO K.P. Reddy visualises the difficulty of automation handling such a variety of fabrics as “one womenswear manufacturer can have upwards of 200 SKUs in a range of fabrics and sizes that rely on a host of operations to go from cut pieces to assembled garments.” (McGregor, L., 2016)

After the launch of the fully automated T-shirt operation line in summer 2018, similar product groups like polos, sweatshirts etc. are projected to follow. In mid-late 2018, Softwear Automation is planning to start its development for an entire new, fully automated production line in garment manufacturing, namely denims. (Simon, A., 2017)

An additional upcoming challenge is the willingness of manufacturers to adapt to this new business model and amend its usual routine. The business management has to be reorganised accordingly (Reddy, K., 2016). K.P. Reddy predicts that in the next 5 to 10 years garment factories can be fully automated (McGregor, L., 2016).

### 5.4.4 INVESTMENT COSTS AND POSSIBLE INVESTORS

The T-shirt production line estimated investment costs amount to one to two million USD\(^\text{13}\). For a Chinese manufacturer investing in this innovation, Softwear Automation predicts recovery of costs within five years\(^\text{14}\). (Simon, A., 2017)

Not only companies from developed countries like USA and Europe show interest in this technology, but also many incoming requests are received from low cost countries like China and Bangladesh, India or Sri Lanka (LaWell, M., 2017). The reason behind this is a rising shortage of skilled, local seamstresses within factory proximity, even in traditional outsourcing markets. The trend worldwide is to migrate to cities

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\(^{13}\) The projected price varies on the number of processes in the production line and depends on extra customisation wishes. The price is excluding machine maintenance costs, but is including an extensive training provided by Softwear Automations for buyers on self-maintenance in case of any trouble shootings (Simon, A., 2017)

\(^{14}\) Estimation is based on China’s labour costs. (Simon, A., 2017) Please find a direct comparison analysis in chapter 6.6
away from factory bases, which are typically found in rural areas. On top of this, the pressure of low prices and high speed-to-market demanded by fickle consumer habits influence the decision to invest in automated production lines. (Reddy, K., 2016) Also, some classic outsourcing countries just feel the pressure to be outplayed if not adapting to robotization (LaWell, M., 2017).

Interested parties range from brands, sourcing partners to contract manufacturers, primarily interested in mass-production (LaWell, M., 2017). All show the same interest seeking to SEWLOCAL™. Absorbing the trend, not only brands try to set up manufacturing closer to the consumer market for more responsiveness on fast-pacing trends, but also manufacturers aim to stay on top of the game by establishing smaller operations in key distribution destinations. (cf. Simon, A., 2017)

5.5 CONCLUSION

CAD systems ease the design process, whilst in the cutting department, efficient CAD-controlled lay planning and automated cutting machines facilitate and speed up production, which in turn results in minimized waste.

In general, automation advances quality, capacity, speed, risks and sustainability. For now, Sewbots have a big market opportunity, but still need to prove its assertiveness. Seamless knitting, however, is already an established technology, which scores in terms of production speed and cost-efficiency, as well in minimized yarn consumption.

To summarize, the benefit of having control over the apparel production process makes the business more independent and flexible for optimization. The dependency on supplier and non-dischargeable promises hence lie in the past.
6 FINAL COMPARISON

In order to be able to answer the question “to what extent are automated technologies a substitute for classic outsourcing in the garment manufacturing industry” a final comparison of traditional outsourcing versus automation will be conducted in this chapter. For consistency, the framework of sourcing aspects, speed, capacity, quality, risk, people and costs is applied for the analysis.

6.1 SPEED

In accordance with consumer demands, speed is a crucial aspect in the fast-paced apparel industry. While the lead-time of an outsourced garment from design to finish normally takes in total around a year, automation can minimize the process to days or hours by “no shoring” production (Murray-Nag, B., 2017). The term “no-shoring” is used for re-shoring back to the homeland by means of automation (Investopia online). This enables speed to market and cost-effectiveness due to direct savings in logistic costs and time, but also flexibility in trend or quality adaptations, which results in improved sustainability (Smits, C., 2017; Simon, A., 2017). Overall, a shortened supply chain is “better suited to changing consumer habits” (Simon, A., 2017) then classic outsourcing.

For knits, research revealed that production of complete garment machines have partly already been in proximity thinking of Italy, Spain and France for the European market. With the fruition of mass-customisation, this would even mean to no-shore production to the home base, or even produce in-store. With the realisation of no-shoring, especially trend items don’t have to be sourced from faraway destinations any longer.

6.2 CAPACITY

Compared to outsourcing, one advantage automation brings in regards to capacity is that machines could theoretically run 24 hours, 365 days a year, without any sick leaves, holidays or over hours of employees, which logically increases efficiency. As a reminder, for a 24 hours shift, factory workers are required to receive triple the usual salary. (Chang, J., et al., 2016)

Referring to the latest knit technology, the capacity of the machines stay the same, even when customising each item individually. This happens without time-consuming reprogramming and thus dependency on mass-production, since state of the art software allows personalised one-time orders for identical costs per unit (Unmade online). Still, if a company is geared on achieving high outputs instead of customised products, selling for low prices, other knit technologies shall be considered.
For Sewbots, the capacity increases drastically. With projected 520 T-shirts per production line within an hour\textsuperscript{15}, robotization challenges conventional mass-production, as for example one Bangladeshi manufacturer only achieves 250 T-shirts\textsuperscript{16} per production line per hour (Uchatius, W., 2010).

However, for now, the variety in products through advanced automated technology, may it be in knitting or sewing is still limited. Outsourcing, or rather human craftsmanship can score in its multifaceted garment creation possibilities. It has the ability to handle any kind of fabric, may it be formable or rigid.

Despite automation, “brands will still outsource parts of their manufacturing to traditional manufacturers who instead of employing 1000s of workers will now hire 300-500 people to maintain and operate the machine” (Simon, A., 2017). In the footwear sector, Adidas’ automated Speedfactory is a good example for this explanation. For Adidas, automation is not seen as a replacement, but more as an addition to traditional outsourcing\textsuperscript{17}. With a total of 360 million produced pairs of shoes in 2016 (2015: 301 million) and the aim to reach the 400 million mark in 2017, the output of Speedfactory only accounts to 0.33\% of its total offer\textsuperscript{18} (Adidas, 2016; Weiss, M., 2017). This illustrates that Speedfactory is more seen as supplement, which enables the company to deliver on speed to react faster on innovative trend pieces\textsuperscript{19} and personalized sneakers. (cf. Meyer, D., 2016)

### 6.3 QUALITY

With automated manufacturing technologies, better quality is achievable through greater precision and the reduction of human errors, which in turn provides a more consistent and improved final product quality (Postrel, V., 2016). CEO K.P. Reddy of Softwear Automation especially highlights the precision of automation and concludes that it “is much greater so there is less wasted product.” (Chang, J., et al., 2016)

### 6.4 RISK & SUSTAINABILITY

Currently, one of the major problems the fashion industry faces with outsourcing is fighting poor working conditions in developing countries. Unhealthy work environments, underpayment, and child labour have been some of the negative aspects, which expose companies to a high risk.

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\textsuperscript{15} Yearly output: 1,000,000, hourly output: 520 (8 hour shift)

\textsuperscript{16} In order to achieve this output workers in developing countries often work 10-12 hour shifts (Uchatius, W., 2010).

\textsuperscript{17} Adidas production in footwear by region in 2016: 97\% Asia, 2\% United States, 1\% in Europe (Adidas, 2016)

\textsuperscript{18} In total, Adidas Speedfactory is able to produce on a large-scale with 500,000 pairs of shoes annually in each of their two factories (Meyer, D., 2016). The percentage is based on following calculation: 1,000,000 / 301,000,000 x 100 = 0.33\%

\textsuperscript{19} Such as Adidas, 3D printed shoe, which shall go into series production with 100,000 pairs of sneakers end of 2018 (Kharpal, A., 2017)
Automation, on the other hand, is able to improve the workplace safety. Considering commonly occurring off-the-clock in developing countries, a lack of concentration can result in poor quality and reduced safety of the workers. Applying automation in garment manufacturing limits the risk for companies to be blamed for recklessness of applied poor working conditions. Events like “Rana Plaza” where 1,136 people died in 2013 would be headlines of the past. (Morgen, A., 2015)

It can also prevent the risk of high stock. Outsourcing profits from large orders. If, however, automation brings no-shoring, time can be saved and out of stock articles can be produced more economically, on demand, and thus set an end to overproduction. This is capturing the trend of a shorter supply chain and a greener future. Based on automation, there will be a focus on less consumption, which in return triggers a change in the retail environment.

In general, it can be said that automation also contributes to a more sustainable environment due to waste reduction. For knits, the possibility persists to knit an entire garment to dimension, saving 14% up to 30% fabric loss compared to other production methods. Waste saving for woven pieces already begins at the process of lay planning by programming and optimizing automated cutting machines to the least possible waste (Eberle H., et al., 2013). Additionally, sewing automation eliminates human errors and thus cull due to machines half-a-millimetre accuracy (Postrel, V., 2016). Nevertheless, should a fault for the robots occur, a 100% loss of a garment must be calculated. (Arkko, T., 2013)

6.5 PEOPLE

The dominant current production method engrosses abundant cheap labour. Therefore production is outsourced to an industrial environment, in which people can provide simple operation tasks like sewing for a minimal wage.

The introduction of automation, on the other hand, is challenging this way of manufacturing. With automated manufacturing in the apparel industry, a smaller workforce is needed, which was demonstrated with complete knitting garment machines, automated cutting machines or other automated technologies. The job requirements are shifting from plentiful low skilled labour to less, but higher skilled workers. This development is inevitable. It will lead to cutting of jobs - while it opens up doors for engineers and technicians, who now are required to monitor and maintain the robots. The challenge persists, especially when domestic sewbots reach a working stage, to prepare garment workers for a conversion. (LA Times, 2016)

6.6 COSTS

Whether outsourcing or automating the production costs stay the same in regards to “materials, labour, overhead [costs], etc. with the only major change being a greatly reduced labour cost” (Simon, A., 2017)
for automation. This becomes obvious in both construction areas in the analysis of Adidas Storefactory as well as Softwear Automation. Only people to maintain the machines or for final finishes are required. This would in turn allow a return of production to a company’s homeland. “[A] customer would be able to produce in a high labour market like North America or Western Europe at a cost comparable to producing in China”, Anastasia Simons says (2017). Consequently “shipping costs, taxes, tariffs, duties or any incentives offered for producing locally” could be reduced next to labour costs (Simon, A., 2017). However, if no-shoring production, the costs for the yarn or fabric procurement should be taken into account. Previous sourcing strategies often focused on choosing production facilities in locations, where the price quality ratio of the yarn is the best (Tremblay, S., 2017).

Based on the estimation of Chang, J. et al. (2016), an analysis with the latest reference technology data is conducted to achieve an accurate comparison of future real wage costs versus projected costs of a fully automated T-shirt production line.

![Figure 6.6-1: Estimated Cumulative Automated T-shirt Production Line versus Real Wage Costs of 22 Operators (USD), China, Cambodia, and Thailand, 2017-2027](image)

Estimation is based on best case scenario of projected prices for an automated T-shirt production line (which lies between 1-2mn USD) with an applied annuity calculation at an annual interest rate of five percent. The garment worker’s salary is based on monthly wages in 2015 (Cambodia: 128 SSD, Thailand: 237 USD, China: 321 USD) and extrapolated to 2018 using real wage growth estimates. Calculation takes estimated average inflation rate per year and real wage growth rate over the last 10 years as well as recent trend into account. (See Appendix I)

As Figure 6.6-1 shows, a Chinese manufacturer, investing in a T-shirt Sewbot at the launch in 2018 will break even within the next 5 years, as Anastasia Simon confirmed (Simon, A., 2017). A Sewbot investment in Thailand is not expected to recover its investment before 2025, and therefore rather reasonable to purchase after 2020, considering an expected cost reduction in technology within the coming years. Looking at Cambodia, the country with the current lowest minimum wage chosen for this
exercise remains more economical to keep the traditional production method for at least the next decade. The calculated minimum of ten years to break even for a Sewbot is a rather long investment horizon considering the dynamics of fast fashion. During this time a lot can happen in fashion and its technology advancements.

Furthermore, the calculations are best case scenarios. The costs for a Sewbot however fluctuate, as each investor has different demands, depending on “the number of processes associated with it and any customization that must take place” (Simon, A., 2017). To equip an entire factory with Sewbots, like a Bangladeshi manufacturer specialised in mass-production and an equal output of 30 automated production lines, a minimum investment of 30 million EUR must be calculated (Uchatius, W., 2010).

6.7 CONCLUSION

Recognisable problems of the fashion industry include overproduction, overconsumption, waste and environmental issues. Automation can be a game changer in this regard. It tackles influential trends the garment manufacturing industry deals with such as making use of shorter supply chains and a higher degree of sustainability. It is also more convenient for adapting to constantly shifting consumer behaviour. Automation is therefore the clear winner looking at its sourcing aspects speed, quality, capacity, risk and sustainability. Still, costs are a pivotal obstacle for the integration of automation looking at the example of Sewbots.

Besides, as seen in the analysis, both automated manufacturing examples are as of yet not dominantly presented on the market. The question persists, as with every revolution, if automation gains acceptance at the current state. However, based on the historical development of technology, one can predict that in a few years automation will play an important role. The hurdle of investing in the innovation of automation will become smaller as market players, who stay on the side line will simply be outplayed by others, missing out on a faster and greener production method with higher outputs, flexibility, and efficiency.
7 FINAL CONCLUSION

This thesis had the goal to analyse the subject to what extent automated technologies provide a substitute for classic outsourcing in garment manufacturing. Therefore, the aspects of (classic) outsourcing, future trends shaping the industry, and the application of automation were investigated. This was undertaken to identify drivers of outsourcing decisions and investigate where automation can help to tackle challenges. A final comparison was drawn based on pivotal sourcing aspects in the knit and sewing sector in order to underline main findings and describe the influence of automated technologies.

Automation has the potential to change the sourcing landscape and offers a direct alternative to outsourcing, but the transition is certainly not happening overnight. It enables a shorter supply chain due to on-demand production in a high speed-to-market environment, provides a more sustainable manufacturing practice, promises a higher capacity for more output, and a higher quality due to the elimination of direct human errors. In summary, with regards to speed, quality, capacity, risk, and sustainability, automation has a better head-to-head record overall. Also, in order to react to and take advantage of influential consumer trends especially speed and customisation in the future, automated manufacturing technologies appear to present an appropriate solution for ideal sourcing.

However, in practice, the implementation of automation does not come with ease as it is often linked with considerable investments in terms of time and costs.

In the knitwear sector, automation has been making promising steps since 1995, when the first complete garment machine was launched on the market. 20 years later, the technology reached the breakthrough with software, which enables mass-customisation on the same machines. It reduced the previously highly time-consuming programming, and proves its cost-efficiency by being able to manufacture for the same unit costs as would be the case for a mass-produced product. This innovation has represented the highest degree of automation in apparel manufacturing as of yet. Two major players in the market have proven so far that automation can be an economic concept - Adidas realised its pilot project Storefactory beginning this year and Unmade uses a similar online concept.

However, for the integration of sewbots, there are no existing best practice examples for a successful implementation yet. The reality of an entire basic automated factory still lays 5 up to 10 years away. With its first integration of a fully automated T-shirt production line in apparel manufacturing, the technology will show its assertiveness and future opportunities on the market. Mass-customisation on the other hand appears to be still a vision.

Looking at both sectors knitting and sewing, for now, the offer variety, comparable to a traditional factory driven by human workforce, is still at its inception. Nevertheless, once the first crucial steps are taken,
especially for Sewbots, further advancements are likely to follow quickly, such as Softwear Automation’s projected automated denim operation line.

In general, potential first adaptors for automation are industry leaders, which also happen to be innovation drivers like global, strong revenue-backed brands, retailers and transnational manufacturers with a large R&D budget or subsidies to spend on technologies.

For mass-customised knitwear, it might be interesting for brands or retailers to invest in one up to three 3D knitting machines and its software for in-stores, or group with specialised Knit&Wear factories in proximity. This would potentially add further value to their business side of customisation, which currently gains popularity.

Talking about automated sewing operations, specifically for mass-production, brands, sourcing partners and contract manufacturers have so far showed their interest in fully automated production lines.

With regards to sewbots, automation is a potential substitute for outsourcing in developed countries, speaking of USA and Europe. But also for a country like China, which is seeking for production alternatives due to a changing production environment. In order to be able to keep a leading manufacturing position in the future, local governments push for investments in robotization. For other mass-production nations, which have a low minimum wage, inflation rate, and real wage growth, automation currently presents no obvious alternative, as human labour still is a more cost-effective option. It is likely, that the trend of rapidly rising wages in most developing countries will witness a slowdown or even come to a halt as their economies mature and they make a transition from developing to developed countries, which in turn makes it harder for expensive technologies such as sewbots, to gain acceptance.

Besides, one should not underestimate the historical role sewing has played. Sewing has been a craftsmanship since the beginning of making clothes. The demand for sewing as we know it will always be required, especially when talking about luxury pieces, for which artisanship such as hand sewing belongs to its uniqueness.

For the large companies, currently automation is rather a supplement than a replacement for outsourcing, as shown in the Adidas Speedfactory example for footwear. This model will also be guidance for automation in apparel manufacturing.

In the knit sector, the demand for outsourcing will still be there, especially in commoditized products, which are faster and cheaper to produce with other assembly methods than 3D knitting. However, for higher priced core and fashion items, in particular trend pieces, and customised products, 3D knitting automation will probably be the solution.
In terms of sewing robots, the technology is, for now, more specialised in commoditised products. It can be seen as the automated equivalent to outsourced mass-production, promising higher efficiency with the advantage to manufacture closer to destination hubs and react faster to consumer demands.

Summing it up, automation, at this stage, cannot be seen as a complete substitute for the traditional outsourcing model, but rather as a supplement or complement to achieve effective and reliable production.

Nevertheless, without doubt, the technology of sewbots for the mass-market and 3D knitting for the mass-customised market will influence the sourcing landscape. Consequently, advancement in automation, especially mass-customisation, might outplay factories in developing countries. Factories, especially in developing countries, should stay ahead of their game by upgrading technology and join forces with fashion companies to achieve bigger consumer platforms to keep up with the pace. Corporations, which pay close attention to new technologies and modify their strategies and operations accordingly, will most likely keep up with a more sustainable and efficient future of production. As a consequence, exports from developing to developed countries might decline. Therefore low-cost manufacturing countries should take the opportunity to also focus on local markets for sufficiency.

Automation promises no-shoring. Nevertheless, the question persists, if automation will assert to bring production home. Clothing manufacturing might be still outsourced to a specialised manufacturer, but produced by a robot.

After all, the sum of labour costs for technicians and engineers, the factory rent in the Netherlands, and other factors would be more expensive than for example in China. So, even taking logistic costs into account, running costs are likely to be high. With the question in mind, if it is still economic enough to outsource regarding those aspects, this may provide a further interesting research point to investigate.
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APPENDIX

APPENDIX A: Example of American Apparel

As an example, American Apparel, which promotes fair wages for clothing manufactured in the US, pays an average professional sewer 12 USD per hour (25,000 USD /year) (American Apparel online). For US employers to stay competitive, companies ought to consider an average wage of merely 10.50 USD per hour for a sewing operator (LA Times, 2016). However, in comparison, a garment worker in a developing country like Bangladesh earns around 0.425 USD per hour. This calculation is based on regulated minimum wage for a 40 hours week /8 hours a day, which is 68 USD a month. Yet, this often doesn't apply due to abuse of human rights e.g. unpaid over hours.
APPENDIX B: Apparel Outsourcing on the Example of a T-Shirt

The outsourcing example outlines manufacturing of a simple, white T-shirt in Asia with focus on costs and lead-time. The illustration of a T-shirt is used as a reference point for comparability and as a basis for more complex products. The main question persists, what benefits outsourcing the production of a T-shirt brings to a certain company.

A simple, white T-shirt is a commoditized product, highly competitive on the market and therefore represents a buyer-driven value chain. On these grounds, it is cost efficient for companies to buy in the value from specialists with decentralized production facilities, which have access to an inexpensive and excessive labour force.

For a better visualization of outsourcing costs subsequent figure presents the breakdown cost analysis on the example of a 29 Euro T-shirt (Fashion Revolution, 2017, p.10-11).

Figure B-1: Cost Breakdown of a Sample 29 Euro T-shirt
A company has to calculate expenses for the outsourcing project, where the incoterm negotiated with the factory plays a major role. Depending on the negotiations, transportation and insurance costs, taxes and tariffs, as well as an agency fee, if contracted, have to be added up. These variable costs depend on each company’s supply chain.

The most commonly contracted incoterm is the FOB, free on board (ICC online). The FOB price includes labour costs (0.18 EUR), manufacturing costs, which encompasses material costs, direct labour costs, and manufacturing overhead (3.40 EUR), fix costs (0.27 EUR), and the factory margin (1.15 EUR). In the case of a 29 EUR T-shirt, the FOB price sums up to 5 EUR in total. Once delivered on board by the supplier, the buyer takes over all transportation expenses and insurance costs of 2.19 EUR. According to the arrangement with the factory (payment terms, delivery terms, etc.) and volume with the factory, costs can vary (Piscaer, J., 2014). If sourced with an agency, an extra fee of 1.26 EUR arises. In total, the brand can sell the T-shirt in wholesale for 12 EUR and keep a margin of 3.61 EUR for each T-shirt. In the end, the retailer sells the same T-shirt for 29 EUR with a profit margin of 17 EUR. However, from this profit the brand or retailer still has to pay its employees, rent, and VAT taxes (Piscaer, J., 2014). (cf. Fashion Revolution, 2017, p.10-11)

As comparison, the same T-shirt manufactured in the USA, would cost 7%-16% more in total than in Asia. Indeed, the agent fee, as well as duty costs at the border can be saved and high shipping cost minimized, as products only need to be shipped within the USA. Nevertheless, labour costs are still pivotal and more than 5 times higher than in Asia, considering a minimum wage between 0.90 EUR to 1,39 EUR, compared to 0,18 EUR, for one T-shirt. As a consequence of the higher labour costs, the factory, brand, and retail margin increases accordingly. The end price of the same T-shirt produced in the United States would sell for between 30,98 EUR and 33,68 EUR.

Next to costs, time is an important factor. Obviously, possible shipment methods from manufacturer to buyer are via land, sea, or air, and are consequently differentiating in cost and time. While it takes 10 days on a boat from Turkey to Holland, trucking the distance of 2700 km only takes half, but costs double as much. (Jordaan, H., 2014)

According to Wolfgang Uchatius (2010), transit time from Bangladesh to Germany as a reference port, takes approximately three weeks. One container (12m x 2,5m x 2,5) can transport approx. 34,000 T-shirts, which costs 2,800 EUR for the above mentioned distance. Big customers like H&M can even get the same container for 2,100 EUR with a 25% discount. (Uchatius, W., 2010) Once arrived at the destination port, additional clearance and transportation time to distribution canters have to be considered.
Calculation notes:

1) Percentage of production costs varies due to fluctuating minimum wage in the USA. American Apparel, which promotes fair wages, even sells a T-shirt with a 17% end price increase.

2) Calculated with an average SAM (standard allowed minute) of 8 minutes for a crewneck T-shirt (Sarkar, P., 2011)

3) Increase is calculated by linear scale assumption.
APPENDIX C: Examples of Changes in Standard Outsourcing Drivers

Examples of Wage Increase
The following examples illustrate the development of wages over time in Cambodia, Indonesia, and India, and show how this has negatively influenced the cost advantage.

In Cambodia, garment workers protested for a better living wage with a union labour request of 160 USD in 2013 (Business & Human Rights Resource Center, 2014). The Labour Advisory Committee (LAC), consists out of a 28-man party with 14 government and 14 union and employer members and follows International Labour Organization (ILO) recommendations (Kunthear, M., Rollet, C., 2015, ILO online). The ILO workshop recommendations deals with the minimum wage, which is set by needs of workers and their families, cost of living, inflation, productivity, competitiveness, labour market/employment, profitability of the sector. With these recommendations ILO advises the Minister of Labour, who sets the monthly living wages. Within 4 years, the monthly minimum wage of garment workers increased by US$73 (91.25%). In 2017, the minimum wage was raised to 153 USD, but still doesn't meet the labour union demand of now 171 USD (Baliga, A., Samean, L., 2016).

Wage increase calculation in Cambodia:
Within two years the monthly minimum wage of garment workers raised US$25.
From 2015 to 2016: 140/128*100-100= 9,375%
From 2016 to 2017: 153/128*100-100= 19,53%

Rising wages:
In 2013: US$80 (Business & Human Rights Resource Center, 2014)
In 2014: US$100 (Business & Human Rights Resource Center, 2014)
In 2016: US$140 (Kunthear, M., Rollet, C., 2015)
In 2017: US$153 (Baliga, A., Samean, L., 2016)

In Indonesia, the minimum wage fluctuates from one province to another. While a garment worker in Jakarta can earn 213 USD, someone on West Java only 100 USD a month according to ILO minimum wage data in 2015 (Cowgill, M., et al., 2015). The reason for an increase, undertaken by the government, is to achieve a recovery in the inconsistency between minimum and living wage in less developed provinces. (Lu, S., 2016)
India’s minimum wage, which payment varies in India from region and qualification of worker (skilled, semi-skilled to unskilled), on the other hand, is mainly influenced by its economic situation and set accordingly. Over the last ten years, the consumer price index, a common measure of inflation, averaged 7.9%, which caused the boost of minimum wage (Inflation.eu online). (cf. Lu, S., 2016)

Examples of Currency Appreciation
From 2005, as Figure illustrates, Chinese Yuan (CNY) appreciated strongly versus the USD over a span of the following ten years after the People’s Bank of China gave up their peg. During this time, many companies could have relocated their production facilities to other low-cost economies with a more stable, beneficial currency exchange rate. Before July 2005, 1 USD equalled 8.28 CNY, the pegging level. Withal, in July 2013, the YUAN reached 6.17 CNY per 1 USD, which equalled an average appreciation of 3.61% each year. (Basu, R., Schneider, M., 2015)

Recently, the CNY is governed by China’s artificial devaluation efforts to boost its economy after such rapid appreciation.

On the contrary, Vietnam’s currency, the Dong, has been losing value against the USD continuously for years, displayed in Figure  (Basu, R., Schneider, M., 2015)

![Figure C-1: 2001 - 2016 Historical USDCNY Chart](Source: Trading Economics online)
Examples of Trade Agreements and its Influence

In the past, the Multifibre Agreement (MFA) was drawn up by industrialized countries, which charged quotas on exported goods to discriminate against developing countries. Since its expiration, the World Trade Organisation (WTO) promotes fair trade, and assures that negotiations and (bilateral) trade proceeds frictionless between nations according to their agreements. (WTO online)

Free trade agreements (FTAs) can influence the end price of a product positively. The following paragraph shows an example of such a recent agreement and its possible impacts.

The Trans-Pacific Partnership (TPP) agreement, signed on February 2016, was initiated between 12 member states to promote free trade and boost the economy of those leagued nations. To be correct, the TTP agreement unites the “United States (withdrawn), Japan, Malaysia, Vietnam, Singapore, Brunei, Australia, New Zealand, Canada, Mexico, Chile and Peru” (Adegeest, D., 2016). Comparable with European Union’s “single market”, the TPP nations are able to export without any taxes and duties within the member states. This means clothing manufactured in countries, such as Vietnam or Malaysia, can be exported without any arising duty costs. (Adegeest, D., 2016)

For the US brand Nike, the effect on savings can impact its competitive advantage enormously, which makes it harder for non-TPP-members to compete on the same price level. Since most of Nike’s shoes are produced in Vietnam with 30% tariff costs on each imported pair to the US, the TPP agreement would make it possible to diminish costs and hence influences the end price in stores. If Nike is able to reduce
costs for each pair by 10%, New Balance, the British footwear brand for example will be most likely outplayed with a more expensive consumer price on the US market owing to accruing tariffs. (Adegeest, D., 2016)

However, Nike’s competitive advantage of tariff and duty savings will not come true - at least for now. Due to the United States recent withdraw in January 2017 under presidents Donald Trump’s leadership uncertainty mists the future for the TPP agreement (Smith, D., 2017). This clearly shows that trade agreements are not set in stone and can change over time, e.g. based on international diplomatic relations, basically destroying the basis of what made outsourcing to a certain location viable in the first place.
APPENDIX D: Example of Automation in a Chinese Garment Factory

Chinese’s company Bealead Automatic Machine Co., is an example, which proves the profitability of integrating automation in Chinese garment factories. The company invented a duck feather filling system for jackets, which companies like Moncler, Adidas, and North Face use. It increases efficiency and reduces the required labour force from five to two workers. The two remaining workers need individual training to operate the machine and get additional support of an engineer, who maintains the machine. The machine investment is 33,000 USD. For the buyer, it is possible to be break-even after around one-and-a-half-years taking into account the Chinese minimum wage was 491 USD in 2013. (Chang, J., et al., 2016, p.17)
APPENDIX E: Product, Design and Structure Possibilities on Complete Garment Machines

Most commonly used for this technology are Shima Seiki’s “Wholegarment®” or Stoll’s “Knit&Wear®” machines. For complete garment machines gauge sizes range from 5-21 gauge (Powell, N., 2005; Shima Seiki online). Dependent on machine type, a wide array of product groups can be produced on a complete garment machine - from sweaters, dresses, skirts, pants, jackets and coats to even smaller items such as soft accessories like gloves, socks, leggings, hats, scarves, neckties, bags, purses or wallets. Even design elements like frills and ruffles, lace pattern, intarsia knits, transparent design or dimensional structure patterns can be incorporated. (Shima Seiki online) Depending on machine the conversion of gauges and multi-gauge knitting, is also possible (Powell, N., 2005).

In general, compared to cut&sew goods, panel knitted and fully fashioned garments, the complete garment knitting method is very attractive regarding comfort in fit, due to elimination of seams, zero waste, and little labour intensity with no major workmanship steps included, which also results in cost-savings (Power, E., 2014).
APPENDIX F: Capacity and Output for Adidas ‘Knit For You’ Storefactory

The output depends on design and size of sweater. Therefore calculations are based on the knitting process, which can take 1 hour up to 1,5 hours for one sweater.

Quantity
12h/1-1,5h= 8-12 sweaters
24h/1-1,5h= 16-24 sweaters

● One machine can produce three sweaters simultaneously

8-12 Pullover x 3 = 24-36 Pullover
16-24 Pullover x 3 = 48-72 Pullovers

● The ‘Knit For You’ Storefactory has three STOLL 830S Knit&Wear machines

24-36 Pullover x 3 machines = 72-108 Pullover
48-72 Pullover x 3 machines = 144-216 Pullovers

Source: Adidas Field research, 2017; Adidas Interview, 2017
APPENDIX G: Fully Automated T-shirt Production Line

Source: Softwear Automation online
APPENDIX H: Research & Development

Industry leaders, such as powerful brands and transnational manufacturer invest millions of their revenue in R&D each year to stay competitive (Chang, J., et al., 2016, p.15).

In 2016, Adidas’s R&D investment amounts about 0.8 per cent of net sales, which equals around 164 million EUR (Adidas, 2016, p.71).

Also Esquel, a transnational manufacturer operating in multi-countries, benefits from R&D by investing millions. Technology is its competitive strategy and therefore lies emphasis on employing high skilled engineers. (Chang, J., et al., 2016, p.15)

R&D investments are rather restricted in developing countries due to financing and limitation of skills and experience. Its focus strategy lies on cheap labour. Nevertheless, developing countries profit from technologies, if transnational manufacturer and brands implement those new innovations in its recent sourcing countries. (Chang, J., et al., 2016, p.15)
APPENDIX I: Estimated Cumulative Automated T-shirt Production Line versus Real Wage Costs of 22 Operators (US$), China, Cambodia, and Thailand, 2017-2027

<table>
<thead>
<tr>
<th>Year</th>
<th>Period</th>
<th>Cambodia</th>
<th>Thailand</th>
<th>China</th>
</tr>
</thead>
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<tr>
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<td>1</td>
<td>123,337.69</td>
<td>46,214.99</td>
<td>75,578.99</td>
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<tr>
<td>2019</td>
<td>2</td>
<td>245,675.38</td>
<td>115,881.97</td>
<td>171,447.16</td>
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<tr>
<td>2020</td>
<td>3</td>
<td>370,018.07</td>
<td>189,615.15</td>
<td>273,866.85</td>
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<tr>
<td>2021</td>
<td>4</td>
<td>493,350.76</td>
<td>280,630.42</td>
<td>388,919.32</td>
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<tr>
<td>2022</td>
<td>5</td>
<td>616,688.45</td>
<td>389,374.70</td>
<td>517,748.85</td>
</tr>
<tr>
<td>2023</td>
<td>6</td>
<td>740,026.14</td>
<td>518,647.10</td>
<td>661,583.02</td>
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<tr>
<td>2024</td>
<td>7</td>
<td>853,363.83</td>
<td>671,648.00</td>
<td>822,141.16</td>
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<tr>
<td>2025</td>
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<td>966,701.52</td>
<td>852,038.46</td>
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<td>1,198,919.64</td>
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<tr>
<td>2027</td>
<td>10</td>
<td>1,253,495.90</td>
<td>1,239,233.96</td>
<td>1,418,721.58</td>
</tr>
</tbody>
</table>

Data Source: TradingEconomics.com; Bloomberg