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Chair in Introduction to Business Economics

Artificial Intelligence and the Fashion Industry

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Preface

The thesis investigates the impact of digital technologies and in particular of Artificial Intelligence on the fashion industry.

It is divided in 5 chapters and one Appendix.

Chapter 1 summarizes the strict relationship between technology and dressmaking/fashion overtime and draws on Phyllis Tortora, Dress, *Fashion and Technology – From Prehistory to the Present* (2015).

Chapter 2 examines how digital technologies are profoundly transforming the fashion industry. The chapter builds on the recent OECD report *Going Digital: Shaping Policies, Improving Lives,* (2019) which attempts at giving a comprehensive definition of the digital technology ecosystem and analyses its extensive impact on different sectors.

Chapter 3 considers how Artificial Intelligence (AI) is transforming the fashion sector in different stages: from product design fabrication and assembly to process control, supply chain integration, industrial research and product use, operations automation, customer experience, trend and demand forecasting. The chapter builds on and synthesizes the main findings from the most recent research in the field.

Chapter 4 presents and discusses the findings of a survey on the use of AI in the fashion industry and summarize key results.

Chapter 5 highlights some of the key topics which are analyzed in the thesis and discusses the new "Fashtech" ecosystem and its implication for the future sector.

Appendix 1 contains the Survey.

Editorial Note

The format complies with the editorial rules issued by the LUISS University *Thesis Vademecum* by Prof. Andrea Prencipe. The date of accession of the works available on websites refers to the last editing.

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Source: Boyd (2017).

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1. Introduction: Fashion and Technology

The Fourth industrial revolution introduced by the digital transformation is allowing the fashion industry, like many other sectors, to increase its capacity to produce and use data that was not previously technically or financially feasible.

The most important impact on production and distribution is yet to come. In a recent interview (March 6, 2019) Federico Marchetti, CIO and founder of YOOX talks about how Artificial Intelligence (AI) is not only helping to revolutionize the production - the brand "8" is produced by YOOX through AI-but also in selling and marketing, since big data and AI will allow each customer to have his/her own homepage.

What is dress?

According to Tortora (2015), dress is first and foremost an element of culture whose visibility makes it immediately perceptible, even to the most inattentive observer; it is the identity card of the wearer since it carries a social message, signals a status, and signifies particular activities and specializations.

What is fashion?

Among the different definitions of "fashion", the Cambridge Dictionary indicates: "1) *a style that is popular at a particular time, especially in clothes, hair, make-up, etc.*; 2) *the business that involves producing and selling new styles, especially of clothes, shoes, hair, etc*."

Tortora (2015, p.3) points out that fashion "*can be a synonym for dress*." Barthes (1967, X) points out that the transition from clothes into 'fashion' takes place with the help of words and images describing a garment that then becomes a system of signs.

Fashion, as a way of producing and wearing something that becomes popular at a particular time, can be traced back to king Louis XIV who transformed 18th century Paris and France, into the capital of fashion; the king invented the *système de la mode* as we know it today, and the French luxury goods industry (Moatti et al., 2018). The king understood the importance of media, at the time, mostly visual arts, magazines and books, as an integral component of the *système de la mode*, and subsidized French artists and engravers to produce fashion plates to promote French luxury goods and culture, both at home and abroad (Chrisman-Campbell 2015).

While dress is worn for practical purposes (to cover the body protecting it from atmospheric agents), clothing is charged with a complex set of emotional values from which fashion springs. Fashion is thus an important phenomenon that affects social contexts and moves countries' economies.

Clothing and tecnology

When we think about technology, needles, scissors, stone cutting tools, or a spinning wheel do not immediately come to mind; rather, we think about computers, smartphones, autonomous vehicles, robots, Artificial Intelligence, IOT, airspace industry, etc. In the current conversation, the word "technology" overlaps with high-tech.

Technology has always been a part of dress-making– or for that matter, of any human activity –, since the very beginning of the human history. Like any other craftsmanship, making garments requires specific tools but also specific knowledge on how to use them properly.

Since prehistory, human beings felt the need to protect themselves from the cold and heat. Ornaments were also commonly used; archeologists found beads in burial sites since the Upper Paleolithic and Neolithic periods. Yet, the making required relatively advanced technology, and specialized and sophisticated tools. With the Neolithic or Agricultural revolution (7000-3000 BCE), the sedentary lifestyle (settling into villages, farming and the availability of plants that provided food and fibers) fostered the production of textiles: linen and wool for weaving.

In the late 17th and early 18th centuries a great number of innovations and patents emerged that greatly enhanced the production and use of garments. The modern textile industry was born in the UK following several technological advances.

The flying shuttle, patented in 1733 by John Kay, doubled weaving productivity and introduced a radical transformation in the history of textiles and dressing. In 1737, John Wyatt and Lewis Paul invented the first powered spinning machine. In 1765, James Hargreaves invented the Spinning Jenny, that allowed one worker to spin multiple spools of yarn at the same time. In 1769, Richard Arkwright invented the spinning frame. In 1769, James Watt patented his steam engine. The innovation soon spread to US. By 1847, more Americans worked in textiles than in any other industry.

Thanks to the introduction of machines in the production process, the foundations were laid to transform the sector from a small manufacturing system to that of large industry.

Yet, the sewing machine was the greatest advance in fashion technology. In 1851, Isaac Singer patented the first sewing machine; the innovation led to manufacturing pieces at a much faster pace, reducing the cost of making clothing and thus allowing consumers to buy more. The sewing machine was widely adopted not only in factories but also among home sewers thanks to Singer's innovative marketing campaign, and the possibility of being able to make the purchase by installments.

For centuries, dressing fashionably was class-structured as it was the privilege of the ruling and upper classes. Innovation and technology contributed to the democratization of fashion and the creation of a mass market.

The sewing machine, together with the tape measure (1820) and patents for paper patterns (1850), democratized fashion, and made mass-production possible. While made-to-measure clothes were a time-consuming affair which involved being measured, choosing a style and fabric, and having numerous fittings, ready-to-wear clothes were available for trying and buying in department stores (1850, US). At the same time, the first fashion magazines became popular, creating the fashion system (Tortora 2015, p. 121; pp. 132-137).

The first fashion trendsetters were based in Paris: Paul Poiret, Gabrielle Chanel and Jean Patou. By 1920, some famous designers added ready-to-wear lines to their made-to-order collections. The fashion centers extended soon to Italy, UK and US, and later, Japan. During the 60s, workshops were increasingly transformed into factories; designers focused more on technologies and the development of machines (Lectra, Gerber) to automatize processes. Courrèges was among the first to value innovation in manufacturing, considering ready-to-wear lines as important as “haute couture” (Moatti et al., 2018).

Fabric was another area of great innovation. Historically, fabrics have been obtained by processing a relatively limited number of natural fibers: wool, cotton, silk, linen. The introduction of manufactured fibers (cellulose acetate, nylon, polyester) completely revolutionized the textile industry, opening up a myriad of unexplored possibilities for clothing and stockings.

During the 80s, globalization fostered textile and apparel imports, especially from developing countries. In order to manage the great variety of products and large volumes of information more efficiently and connect with companies from any part of the world, fashion was quick to adopt technological processes and the use of EDI (Electronic Data Interchange) for its logistics operations and the exchange of business documents. Since then, there has been a constant evolution in equipment, information systems and technology (Moatti et al. 2018).

2. Digital Transformation & the Fashion Industry

2.1 Digital Transformation

The previous chapter showed that technology has always played an important role in fashion. This is particularly true today for digital technologies that are profoundly transforming the fashion industry. Digital transformation seems to be the new buzzword for many industries. A search on Google gives almost 450,000 results for this expression. How can digital transformation be defined?

According to the OECD (2019, p. 17): "*Digital transformation refers to the economic and societal effects of digitization and digitalization. Digitization is the conversion of analogue data and processes into a machine-readable format. Digitalization is the use of digital technologies and data as well as interconnection that results in new or changes to existing activities*."

Digital transformation implies two processes: digitization and digitalization. Digitization is the encoding of information or procedures into binary bits i.e. 0 &1 that can be read and manipulated by computers. It implies the conversion of analogue content into binary code as occurred with CDs and DVDs. The information in digital form can be used to perform functions and undergo manipulations that can offer the primary input for the expansion of emerging digital technologies. For instance, data in digital format can be reused, copied and moved very quickly without degradation. Digitalization uses digital technologies, data and interconnections to change or create new activities. Interconnection of devices and networks has enabled the development of digitalization and has been at the heart of the spread of information and communications technologies (ICTs). ICTs represent the combination of once separate concepts:

- IT (Information technology): hardware and software used to access, copy, memorize and use information in electronic form;

- CT (Communications Technology): devices, infrastructure and the software used to send and receive information (modems, digital networks, high speed internet access).

Therefore, Information and Communications Technology (ICT) can be defined as the integration of information processing, computing and communications technologies.

The pervasive nature of ICTs and the digitalization of networks is contributing to the development of ubiquitous digital devices, high broadband connectivity, applications and services that are empowering individuals and organizations to change behaviors, ways of doing business and markets.

2.1.1 The digital technology ecosystem

Digitization and the development of Information and Communication Technologies have created an ecosystem of digital technologies: some are already in place and others are still on the way (OECD 2019, pp. 17-21). Figure 2.1 presents the major technologies of the ecosystem. These technologies are interdependent and make the ecosystem stronger and more functional than each individual component.

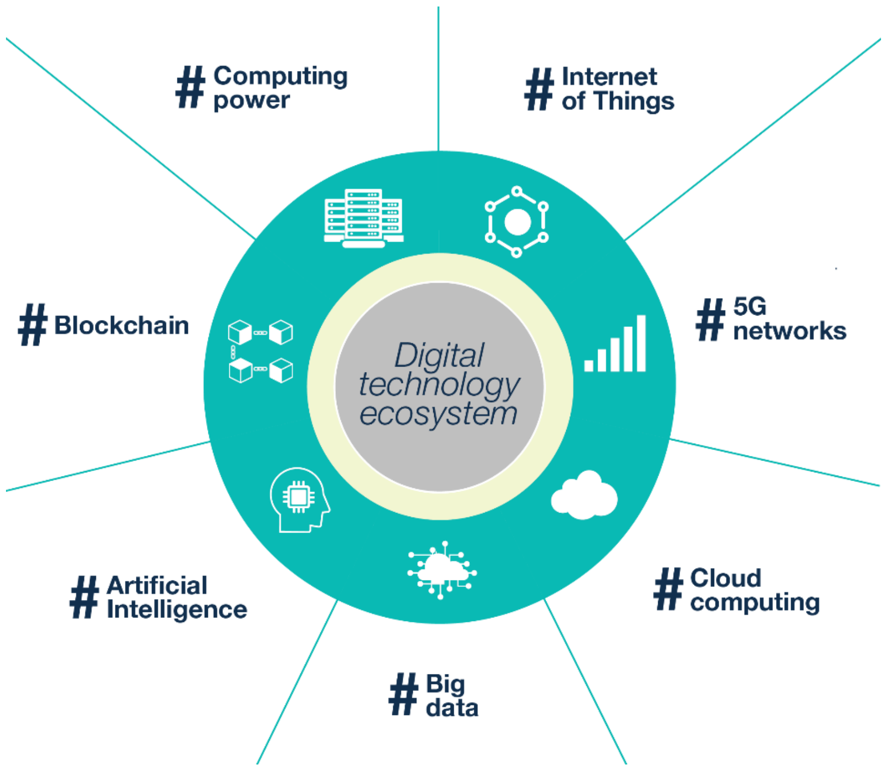
Internet of things

For Internet of things (IoT) is meant an extension of Internet connectivity to objects that “talk” to each other. These objects range from simple sensors to smart phones and wearables and can be remotely monitored and controlled. IoT fuels machine to machine communications, typically involving sensors for smart cities, agriculture, manufacturing, health and location of people and animals, but also advanced applications like connected and autonomous vehicles (Burgess 2018).

Next-generation wireless networks: “5G”

The major difference with previous wireless technologies (such as 3 or 4G), is that 5G is designed to connect not only people but things, objects such as self-driving vehicles, roads and traffic lights and, more generally, to connect billions of machines to other machines. 5G will provide higher speeds (i.e. 200 times faster than 4G), faster data transfer (i.e. transfers taking 10 times less long than 4G) and more flexibility and better support for ad hoc applications through the virtualization of the physical layers (i.e. “network slicing”).

Figure 2.1. An ecosystem of interdependent digital technologies



Source: OECD, 2019.

Cloud computing

Cloud computing allows clients to have a flexible, on-demand access to a range of computing resources such as software applications, storage capacity, networking and computer power. These resources can be used and priced according to customer needs, transforming fixed costs for information and communication technologies into variable costs and allowing customers to rent the services they need at any given time, instead of buying them.

Big data analytics

"Big Data" usually means data characterized by high volume, velocity and variety. IoT, among other technologies, is the major source of big data while cloud computing offers the source of computing power. Although large quantities of data can be considered valuable in themselves, the greatest value of the data is generated by extracting information from it. Big data analytics techniques and specialized software are used for purposes of profiling clients, data mining and other applications. Using big data makes it possible to improve production processes and supply chain management and enable data-driven increases in innovation and productivity.

Artificial intelligence

According to the Artificial Intelligence High Level Group of the European Commission (2019): "*Artificial intelligence (AI) refers to systems that display intelligent behavior by analyzing their environment and taking actions – with some degree of autonomy – to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications)*".

Blockchain

Blockchain is a technology that allows applications to authenticate ownership and carry out secure transactions for a variety of asset types. It is based on a decentralized ledger that relies on cryptographic algorithms and economic incentives in order to ensure the integrity and legitimacy of every transaction. A copy of the blockchain is shared across all nodes connected to the network, which comprises the history of all valid transactions. Each transaction is recorded into a "block" which is appended sequentially to the previous block of transactions. Once information has been recorded onto the blockchain, it can no longer be edited or deleted. The result is a long chain of blocks that represents the whole chain of transactions since the first genesis block. In view of its decentralized nature, the security of the blockchain and the validity of every transaction can only be ensured through distributed consensus i.e. through nodes verifying the integrity and legitimacy of each block, independently of any trusted third party (De Filippi et al., 2016).

Computing Power

High-performance computing (HPC) is the aggregation of processing power to deliver much greater performance than would be possible with a classical computer. *Quantum computing (QC)* is a subset of HPC, but it takes a fundamentally different approach. "*All computing systems rely on a fundamental ability to store and manipulate information. Quantum computers leverage quantum mechanical phenomena to manipulate information. To do this, they rely on quantum bits, or qubits. Universal quantum computers leverage the quantum mechanical phenomena of superposition and entanglement to create states that scale exponentially with number of qubits, or quantum bits*" (IBM 2019), allowing for enormous processing power that will make possible to solve challenges that today's systems will never be able to do.

2.1.2 Digital Transformation: ecommerce

Digital transformation is creating new business models and it is enabling firms to sell on digital markets, digitalize business processes and adopt new organizational models. Firms that operate online platforms and firms that combine online and offline features, are among the most relevant business models emerged over past decades. Online platforms are becoming widespread since they help in facilitating and structuring online interaction and transactions. There are also more traditional companies that are moving online and are combining online and offline sale channels.

E-commerce has emerged as an economic and social phenomenon over the last 25 years, facilitating trade across borders, increasing convenience for consumers and enabling firms to reach new markets. According to the OECD (OECD 2019b, p. 58), in 2017 about 60% of online purchases across the OECD countries were in clothing, footwear or sporting goods, while fewer people bought movies, films, images and music products (30%), computer games or video games and computer software (21%) or food, alcohol, or cosmetics (17%).

The long tail of e-commerce allow customer to buy niche products and find items that are more difficult to find in the stores, for instance, for plus sizes or for other nontraditional sizes (Anderson 2006).

E-commerce websites like Farfetch (Abbafati 2017) and YOOX NET-A-PORTER Group, both specialized in luxury brands, have contributed to the “democratization of luxury” as Federico Marchetti, CIO and founder of YOOX, pointed out in a 2012 interview for the magazine “The New Yorker.”

Some companies, such as Rent the Runway or Rent Frock Repeat, offer dress rentals through their e-commerce sites for a fraction of the retail price as an alternative to purchasing; the subscribers of their services can rent expensive dresses that are rarely used.

Furthermore, online transactions collect detailed data about individuals (name, gender, age, etc.), purchasing history, browsing history, IP address, etc. This data is particularly useful, since it can help target product offerings, increase consumer awareness (for instance, through recommendations based on previous purchases) and is essential for the customization and personalization that consumers want (OECD 2019b, p.71).

2.1.3 Datafication of fashion

The digital transformation is allowing the fashion industry, like many other sectors, to increase its capacity to produce and use data that was not previously technically or financially feasible. *Datafication* refers to data generation through the digitization of content, and monitoring of activities, including real world activities and phenomena, through sensors (OECD 2015 p. 34). The datafication of fashion refers to the capacity to create digital data in relation to fashion products and production processes, allowing them to be monitored, tracked, analyzed and optimized.

The data, gathered through e-commerce, direct and online sales (fast fashion such as Zara and H&M selling in-store and online) and social media (Facebook, Blogs, Instagram, etc.), is making the fashion sector both an important consumer and supplier of data that can be useful to obtain a more direct feedback loop to inform production decisions, improve planning and logistics, customize products, etc. Moreover, fashion data can also be used to feed into the rest of the value chain: wholesalers, retailers, finance and product input sectors such as textiles and leather (OECD 2019, p. 25).

Access and use of data along the value chain can increase the efficiency and resilience of the fashion value chain – for instance, through traceability, assisting in certification of standards and by facilitating trade logistics chains. There is growing demand, for instance, for traceability and transparency for the purposes of monitoring pirated goods and illicit trade, and to support tracing and tracking.

The creation of new data and knowledge using digital technologies is thus enabling the fashion sector to be better understood, and managed, reducing uncertainty and increasing co-ordination. The digital transformation provides tools for reducing information asymmetries and creating knowledge about markets, products and opportunities; it can therefore support better differentiation of products and can open up new markets.

Thanks to digital technologies, consumers are playing an active role in transforming fashion; it is not only what customers buy but also what they post on Instagram showing what they wear to millions of potential customers. At the beginning, the king dictated the style; then came the fashion magazines, and the star system (movies stars, singers, performing artists, etc.); today, everyone can be a fashion expert and influencer. (Taroy 2015).

2.2 Key technologies for the future of fashion

How is the fashion industry interacting with digital technologies? And in particular, what are the most relevant technologies for the future of fashion? Alcimed (2017), a French consulting company, identifies the following **11 technologies** as key to ensure the agility and competitiveness of the French fashion industry:

- Cloud
- Big Data
- Artificial Intelligence
- Cybersecurity
- Tags
- RFID
- IoT
- Robots/Cobots
- Drones
- Additive manufacturing
- Immersive technologies

We have already described many of these technologies in the previous chapter as part of the digital ecosystem. Therefore, we will complete the description for the following ones:

Cybersecurity: According to Alcimed, cybersecurity is based on the following technologies: big data, AI, electronic signatures, encryption and blockchain**.** Electronic signatures, encryption and blockchain are used to guarantee the confidentiality and integrity of data and online transactions.

RFID: RFID is an acronym for "radio-frequency identification" and involves a technology that allows to automatically identify, and track tags attached to objects. RFID systems are made by three components: an RFID tag or smart label, an RFID reader and an antenna. RFID is similar to barcoding but, unlike a barcode, the tag does not need to be aligned with an optical scanner so it may be embedded in the tracked object. RFID (Radio-Frequency Identification) is one method of automatic identification and data capture (AIDC).

TAG: According to Alcimed, tags are tools, like labels, that are integrated into clothes and make it possible to detect and acquire in real time personal information such as breathing, motion, posture, as well as environmental information such as temperature and pollution.

Additive Manufacturing: Traditional manufacturing methods involve a material being carved or shaped into the desired product by parts of it being removed in a variety of ways. Additive manufacturing is the polar opposite; the product is created through the addition of thousands of minuscule layers. The process involves the use of a computer and special CAD software that can relay messages to the printer so it "prints" in the desired shape. Suitable for use with a range of different materials, the cartridge is loaded with the relevant substance and this is "printed" into the shape, one wafer-thin layer at a time. These layers are repeatedly printed on top of each other, being fused together during the process until the shape is complete. 3D Printing, Rapid Prototyping and Selective Laser Sintering are all processes that are typical of additive manufacturing (SPI Lasers Insights 2019).

Drones: According to Alcimed, a drone is a particular type of robot with an extensive capacity to move but limited autonomy (from a few minutes to five days). There are drones able to operate on land, water or air and with various degrees of autonomy, either under remote control by a human operator or autonomously by onboard computers. Like a robot, a drone is programmed in advance to do a specific task.

Immersive Technologies: Immersive technologies encompass both augmented reality (a real environment with some fictitious elements) and virtual reality (an immersion in a completely fictitious environment). These technologies allow customers to interact with an environment that they can modify.

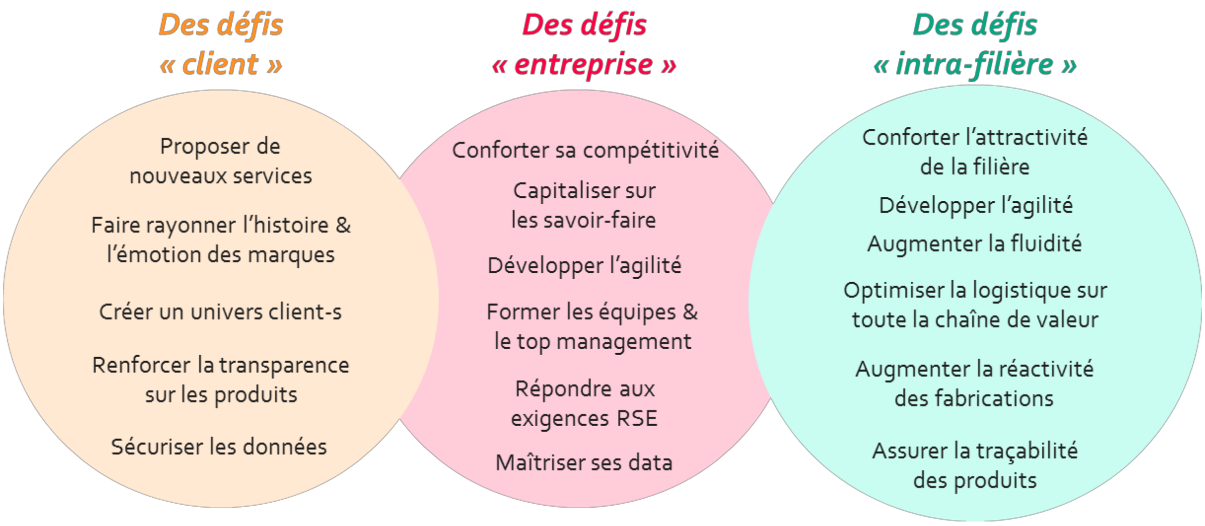
Alcimed (2017) claims that these technologies will be fundamental in responding to the specific challenges that the fashion industry is facing today:

- The "**Client**" challenge, concerning the relationship of the fashion industry value chain with the consumers;

- The "**Enterprise**" challenge, concerning the performance of each firm within the fashion industry value chain;
- The "Intra-**Value Chain**" challenge, concerning the interaction among the various links of the fashion industry value chain.

Figure 2.2 characterizes the different challenges in more detail.

Figure 2.2



Source: Alcimed, 2017.

Furthermore, Alcimed, suggests in which links of the fashion industry value chain each technology could play a specific role. Figures 2.3 and 2.4 summarize this information

Figure 2.3

Technology	Challenges	Links of the Value Chain
Cloud	C, E, IF	CREATION, USAGES, FABRICATION, LOGISTIQUE, DISTRIBUTION, COMMUNICATION
Big data	C, E, IF	CREATION, USAGES, FABRICATION, LOGISTIQUE, DISTRIBUTION, COMMUNICATION
Intelligence Artificielle	C, E, IF	CREATION, USAGES, FABRICATION, LOGISTIQUE, DISTRIBUTION, COMMUNICATION
RFID	C, E, IF	FABRICATION, LOGISTIQUE, DISTRIBUTION, COMMUNICATION
Capteurs	C, IF	CREATION, USAGES, FABRICATION, COMMUNICATION

Source: Alcimed, 2017.

Figure 2.4

Technology	Challenges	Links of the Value Chain
Cybersécurité	C, E, IF	CREATION, USAGES, FABRICATION, LOGISTIQUE, DISTRIBUTION, COMMUNICATION
Internet des objets	C, E, IF	CREATION, USAGES, FABRICATION, LOGISTIQUE, DISTRIBUTION, COMMUNICATION
Robotique / Cobotique	C, E, IF	FABRICATION, LOGISTIQUE, DISTRIBUTION, COMMUNICATION
Fabrication additive	C, E, IF	CREATION, FABRICATION, COMMUNICATION
Drones	C, E, IF	CREATION, USAGES, FABRICATION, LOGISTIQUE, DISTRIBUTION, COMMUNICATION
Technologies immersives	C, E	CREATION, USAGES, FABRICATION, LOGISTIQUE, DISTRIBUTION, COMMUNICATION

Source: Alcimed, 2017.

Yet, the most important impact on production and distribution is yet to come: Artificial Intelligence may transform the fashion sector entirely. Among these technologies, Artificial Intelligence appears the most significant not only because it is strongly interdependent with many other technologies such as Cloud, Big data, RFID, TAGs, IoT and others, but also because it plays a major role in all links of the value chain.

3. Artificial Intelligence & Fashion

3.1 *Artificial Intelligence as a game changer*

The fashion industry is at a turning point. The McKinsey Global Fashion Index (2018) forecasts that industry sales growth will triple from 2016 to 2018, from 1.5% to between 3.5% to 4.5%. This growth is characterized by two phenomena: 1) the West will no longer play the major role in fashion sales and more than half of apparel sales will come from emerging market countries across Asia-Pacific, Latin America and other regions; 2) the adoption of digital technologies such as mobile internet, advanced analytics, virtual and augmented reality, advanced robotics and artificial intelligence are profoundly changing the industry and setting the stage for a strong trend towards a decisive phase of digital adoption by mainstream consumers; these processes are geared to match some specific trends in customer and enterprise behavior.

3.1.1 *Getting personal*

According to the McKinsey 2018, personalization is identified as the number one trend for the fashion industry. Consumers have a strong desire to use fashion to express their own style, image and values. At the same time, customers are becoming pickier, looking for unconventional items and products with higher quality, exclusivity and better prices. Therefore, fashion companies will offer personalization in many ways, ranging from more customized products to enhancing consumer experience both in physical and online shopping. First, this is accomplished by customizing shopping experiences, based on major investments in data collection and data analytics capacity. For instance, Stitch Fix works as personal stylist, using an algorithm to deliver packages of pre-assorted personalized clothing to consumers monthly. Sephora uses data from customers' online shopping histories, by utilizing beacons in their stores which send smartphone notifications when customers are close to an item that they have previously put in a digital shopping cart. Second, retail services offered in physical stores are enhanced by providing smart dressing rooms, digital mirrors and automatic payments systems that let customers skip check-out lines. Third, 3D visualization is used in online retail for designing and personalizing products such as shoes or clothes (OECD 2019c, p. 9).

3.1.2 *Platforms first*

According to the McKinsey 2018, consumers will consider online platforms as the first point of search, given the convenience, the variety and breadth of offering. As multi-side markets, platforms enjoy strong direct and indirect network effects and offer benefits from economies of scale to users on both sides of the market. Acting as intermediaries between buyers and sellers on the internet, they facilitate the exchange of goods and services. They offer a greater variety and quantity of goods compared to physical stores. According to Bloomberg (2017), while the average physical store of Walmart holds approximately 120,000 items for sale, Walmart's online store offers 35 million items for sale. Economists have clearly recognized the positive effects on consumer surplus from the offering of online platforms (Brynjolfsson, Hu and Smith, 2003). Online platforms also help in providing a mechanism to reduce information asymmetry between multiple parties and increase trust in transactions by making them safe and reliable.

Online platforms are also strengthening their position in the fashion sector. Platforms such as Amazon, Zalando and Myntra are promoting their own private label fashion offerings. They are also differentiating their offering in specific sectors such as sportswear or premium and luxury segments. At the same time, fashion brands have to figure out how to collaborate in a mutually convenient way with platforms to avoid that not only their fashion brand but also their customers' data could be used by platforms to build their own label-collections.

3.1.2 Mobile obsessed

Customers will be increasingly using mobile phones for web search, price comparison and their online purchases. The trend is well established in Asia. In countries such as Japan and South Korea, more than half of e-commerce transactions are made on a smartphone or tablet. In China, more than 80% of online shopping is done on mobile devices. Therefore, consumers will expect fashion companies to offer convenient mobile transactions (McKinsey 2018).

3.1.3 Artificial Intelligence gets real

The massive usage of data, growing computer power and the availability of advanced algorithms and key analytics are leading to a tremendous increase in the use of artificial intelligence. The fashion industry will follow this trend and artificial intelligence will be used in all parts of the fashion industry. According to Mckinsey (2018, p. 58), 75% of retailers plan to invest in artificial intelligence over 2018 and 2019 and artificial intelligence in the fashion industry will be used to "*reinvent design, merchandising and marketing, but also to deliver significant speed, cost and flexibility improvement across the fashion supply chain*". But AI also has the potential to completely disrupt the fashion industry, not only because of new business models, new ways of production but also on account of the impact on the people employed in the fashion industry and on their jobs.

3.2 Artificial Intelligence for Fashion

3.2.1 What is Artificial Intelligence?

There are countless definitions of Artificial Intelligence (AI) and no single universally agreed designation (OECD 2019, p. 11; CEPS 2019, p. 8).

In the previous chapter we used the definition provided by the European Commission's High-Level Expert Group on Artificial Intelligence (2019) that refers to AI as "*systems that display intelligent behavior by analyzing their environment and taking actions – with some degree of autonomy – to achieve specific goals. AI-based systems can be purely* *software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications)*."

This definition implies that AI is always part of an IT system and requires some form of hardware (computer power, data storage and connectivity) for data acquisition, but also software for the elaboration of data (CEPS 2019, p 9). Indeed, the evolution of hardware and software will characterize the success of AI technologies.

The principles of AI were conceived in 1956 at Dartmouth College during the first Conference on this topic, led by John McCarthy, a math professor. Since then, a big controversy began between two approaches to AI: Symbolic vs Statistical Approach.

To understand this difference, it is helpful to focus on the distinction between the way in which a child learns a language and the way adults learn a second language. Children learn a language essentially by listening and repeating what they learn. Adults instead tend to think about rules: where to put the subject, verbs, plurals and so on.

In other words, while the brains of children operate on statistical principles to discover the patterns of language, the adult's brain is different, and the adults need to learn the rules clearly when acquiring a new language.

A similar split happened in the AI community: one research group pursued the rule-based or 'symbolic' approach; the other followed statistical pattern recognition systems. While at the beginning, it looked as if the first approach would prevail, later on, the complexity of codifying all relevant rules into computer systems brought up the failure of the symbolic approach. The statistical approach worked towards the creation of systems that learn tasks as a child does with language, i.e. by experience and repetition and through feedback. It created the field of *machine learning* (McAfee et al. 2017, pp.67-72).

The first machine was the Perceptron, a US navy funded project, and it was essentially able to distinguish things, such as dogs versus cats. But it was only recently that with the tremendous increase in computer power (Moore's law), the availability of big data, the explosion of digital text, pictures, sensors and video, that the machine learning systems achieved real breakthroughs.

The most famous breakthrough was the victory of the Alpha GO system over the best human GO player in the world, Lee Sedol, in Korea in March 2016. Alpha GO was a system developed at Google DeepMind, a company specialized in machine learning. The humans that created Alpha GO did not program it with fancy strategies but gave the system access to 30 million positions from an online repository of games and instructed the system to use all these moves to search for victory. The system was also able to play games against itself generating an additional 30 million positions and it focused only on the positions leading to victory ((McAfee et al. 2017, p. 4).

3.2.2 AI basic Characteristics

AI is an overarching category that includes several tools and techniques and application areas.

3.2.2.1 Tools and techniques

The major tool in today's AI systems is **machine learning** (ML); according to OECD ML is: "*a set of techniques to enable machines to learn in an automated manner, without explicit instructions from a human, by relying on patterns and interferences. ML approaches often teach machines to reach an outcome by showing them many examples of correct outcomes, but they can also define a set of rules and let the machine learn by trial and error*" (2019d, p.16).

According to Buchanan et al. (2017, p. 6), machine learning algorithms are usually divided into three large categories: *supervised learning*, *unsupervised learning* and *reinforcement learning*. In supervised learning algorithms, used to make predictions or assessments, the data given to the algorithms already contain the correct answer about the characteristic of interest – for instance is an email spam or not? – (in this sense it is supervised).

Based on this information, the system is able to learn and make predictions using new data. Instead, in unsupervised learning, algorithms are able to cluster the data by themselves without prior information on how to break down data into groups. This methodology could be helpful to sort the multitude of pixels in a picture into a small number of important recognizable features such as mouth, nose or eyes that, for instance, could feed a supervised learning facial recognition algorithm. Reinforcement learning uses software to teach an environment how to act. Reinforcement learning algorithms are very often used in robotics, although the most public success has been in games such as in the case of Alpha GO (Buchanan et al. 2017).

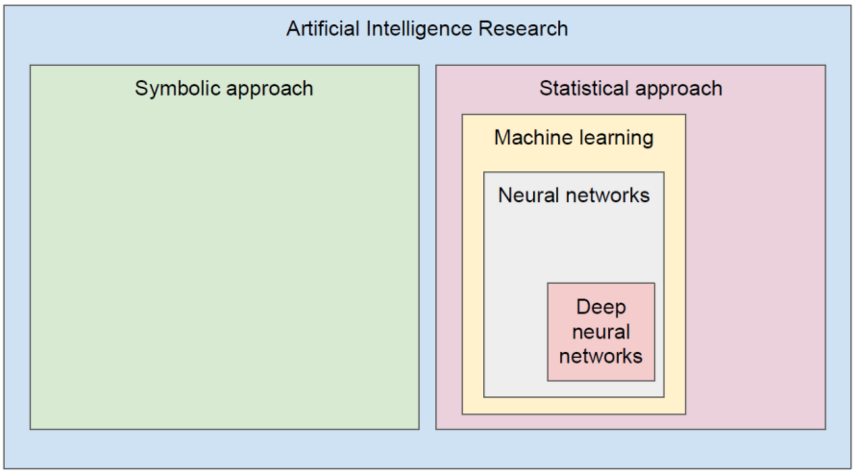
A subcategory of machine learning is **Neural Networks** that are characterized by layers that compute information in parallel and are formed by interconnected nodes that pass information to each other The patterns of this process represent the knowledge in these systems. Neural networks are composed of three basic parts:

- *Input layers* that encompass input data
- *Hidden layers* that contain the synapse architecture
- *Output layers* that provide final results from the network (Luce 2018, p. 13).

Overall, neural networks imply the interconnection among thousands of millions of simple transformations into a statistical machine able to learn sophisticated relationships between input and outputs (OECD 2019d, p. 17).

A subset of neural networks is **deep learning** and is characterized by particularly large neural networks composed of hierarchical layers that increase the complexity of the relationship between input and output. Deep learning is an architecture able to implement supervised, unsupervised and reinforcement learning. Deep learning uses networks with layers of nodes that mimic the neurons of the brain. Each layer of neurons uses the data from the layer below it, makes a calculation and offers its output to the layers above it (Buchanan et al. 2017, p. 15). Figure 3.1 summarizes the relationship between AI and machine learning.

Figure 3.1



Source: MIT IPRI, 2018.

Generative Adversarial Networks (GANs) are another AI technique and are used to improve the efficiency of unsupervised learning. GANs use two separated neural networks: the first one generates results, while the second one evaluates the accuracy of these results. In the fashion industry, GANs were proposed by Amazon in 2017 for creating AI fashion designers (Luce 2019, p. 14).

Data Mining is an AI technique. AI is based on data. Indeed, a decent algorithm that learns from a lot of data outperforms a great algorithm that learns from minimal or poor data. Beside data collection, uncovering useful information from large data sets is what data mining is all about. For instance, for the fashion industry, social media data can be particularly valuable for learning how customers feel about products and trends.

3.2.2.2 Application areas

Natural language processing (NLP). Humans and machines both have languages that meet in natural language processing. Science fiction always envisaged computers that could read, listen, translate, understand and talk. NLP does this type of work and it is a way for machines to comprehend human language. All the text humans produce on the web through posts, text messages and emails is estimated to be unstructured data for almost the 80% of the 2.5 quintillion bytes of data accumulated every day. NLP can be used to understand the context and the content of this data making it possible to discover a wealth of information about ourselves (Luce 2018, p. 11)

Computer Vision (CV). Machine learning lets computers identify objects in pictures. As mentioned before, the different layers of deep learning first identify the pixels of the most important characteristics of an image. Then, these features are passed up to higher layers in the network to learn more about the objects. The last layer, using the previous layer's information, is able to identify the object. CV makes it possible to process and analyze images and videos. This is leading to important applications in medicine, for instance to develop accurate prognoses for lung cancer patients. In the fashion industry, CV is used for visual search, smart mirrors, social shopping, virtual and augmented reality (Buchanan et al.2017; Luce 2019).

Predictive Analytics. To identify upcoming trends, AI uses predictive analytics, based on data mining, statistical methods and machine learning. In particular, in the fashion industry, predictive analytics are used in two areas: recommender systems and demand forecasting. *Recommender systems* try to understand customer behavior and recommend products or services that customers are likely to buy. These systems are used in retail, fashion but also for services like music or Netflix. *Demand forecasting* is used for supply-chain optimization. Through better prediction of demand for products, the fashion industry can reduce inventories, cut costs and decrease waste.

Robotics. The use of robots in the fashion industry is still in its infancy because of the complexities involved in handling fabrics. But, given the improvements in computer vision and advances in algorithms used to perform complex tasks, robots are being adopted in fashion.

3.3 Applications of AI to Fashion

Fashion is one of the most valuable sectors in the world. Its estimated worth is about $3 trillion, representing 2% of Global Domestic Product (Sennaar 2019). However, this industry has remained quite traditional for decades.

As the digital transformation progresses, it is also imposing profound transformations on the fashion industry. In particular, the abundance of data made available by the use of digital technologies has enabled the diffusion of many applications of AI in this industry.

The most widespread applications are in the domain of customer services, bringing the ability to capture the trend of customer personalization by enhancing customer experience online and in stores. Schneider (2017) estimates that AI will manage up to 85% of all B2C interactions by 2020.

3.3.1 Customer experience enhancement online and in-store

Chatbots or AI smart Assistants. The increasing scale and granularity of personalization in online fashion would be impossible to manage without AI applications. The most popular services for personalized online shopping use chatbots or AI smart assistants. These are virtual machines that interact with customers via chat, responding to customer service inquiries, helping users navigate ranges online and in-store, recommending clothing and accessories that best suit a specific customer as if they were human shopping assistants working 24 hours a day.

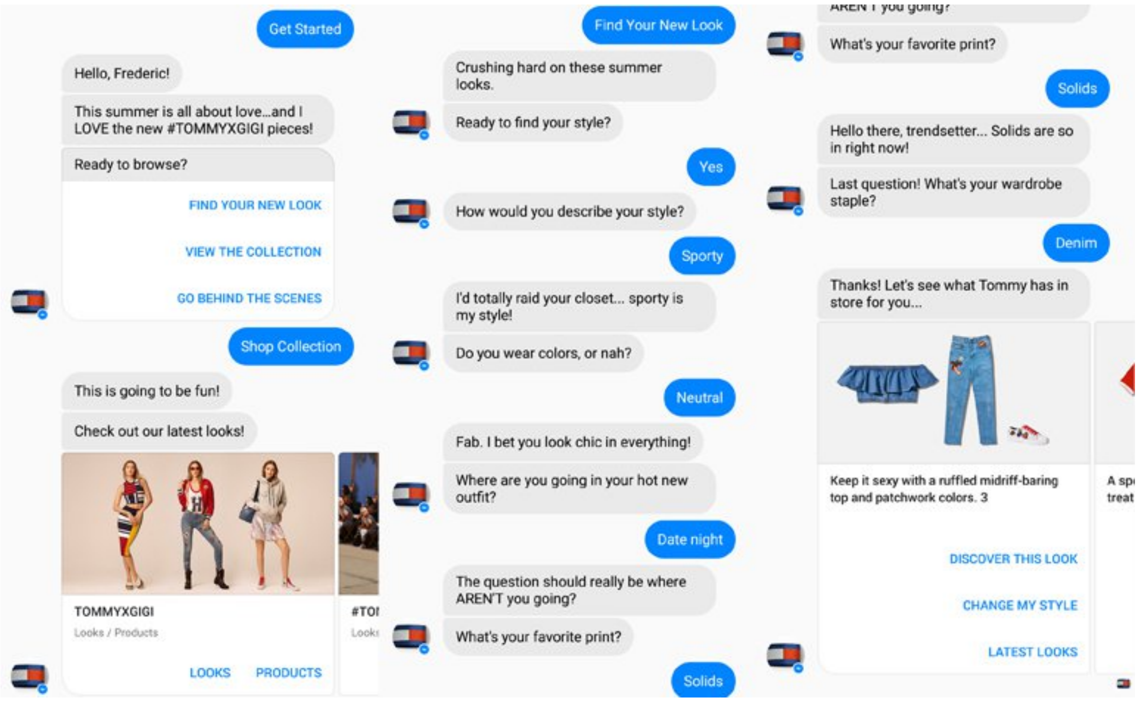
Chatbots can be divided in two categories: scripted and artificially intelligent.

Scripted chatbots are able to follow only a predetermined set of rules. It means that they are only able to answer the questions they are programmed for.

Artificially intelligent chatbots are instead able to interpret human language and are capable of coming up with answers to questions that have not been predefined. Furthermore, there are specialized chatbots specifically for retail applications (Luce 2019 p. 23). Chatbots use natural language processing (NLP) that makes it possible to tailor marketing activities based on linguistic context – such as email, social media posts, customer services contacts and product reviews. ASOS, an online fashion company, increased purchases by 300% using a chatbot, while Levi's, a pioneer in the use of chatbots, partnering with AI companies such as mode.ai, uses them to help customers to find the perfect pair of jeans (Catchoom 2018; OECD 2019d p. 42).

Dior also uses a chatbot to interact with customers via Messenger on Facebook (the platform is called Dior Insider). This service offers the possibility of using slideshows and links to the website, making the shopping experience much easier. Figure 3.2 shows an example of a chatbot.

Figure 3.2. AI Fashion Chatbot



Source: de Bos, 2018.

A subset of natural language processing techniques, **natural language understanding,** helps in the comprehension of the human language. In particular, it makes it possible to implement sentiment analysis, i.e., understanding how the customer, interacting through the chatbot, feels about a particular subject or product (Luce 2019 p. 33).

Research shows that customer satisfaction is higher (73%) with live chat compared with phone or email (Chery Joy 2017).

Chatbots in combination with other technologies could become particularly sophisticated. For instance, Nike partnering with advertising agency R/GA is using IoT data to fuel an AI assistant service, Nike on Demand, to encourage users to maintain a regular exercise pattern.

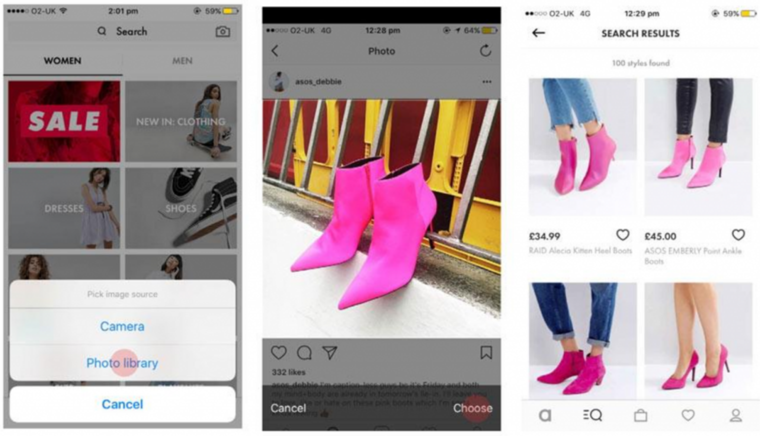
Image Search. Personalized shopping is also achieved using AI applications based on computer vision and augmented and virtual reality. Indeed, fashion is probably one of the industries that relies the most on images. Image search usually refers to the process of finding images using a text input. Search engines as Google introduced this possibility since 2001.

Reverse image search instead is the process by which an image is used to find another image.

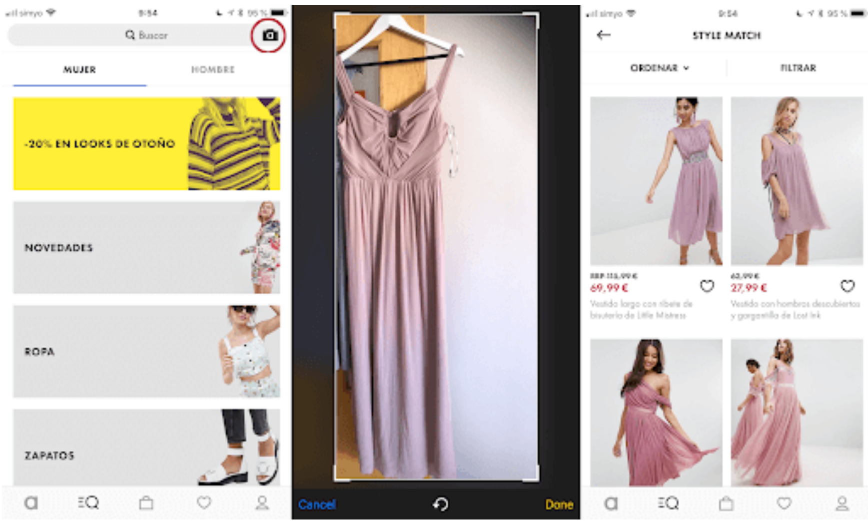
Visual search, a subset of reverse image search, refers to the possibility of finding items within an image and searching for those. This, for instance, would make it possible to search for a similar pair of shoes in an image. While computer vision makes seeing objects possible, machine learning, and in particular neural networks, makes recognizing them possible. The combination of computer vision and neural networks is leading to interesting applications of AI in fashion (Luce 2019 p. 55).

The online fashion retailer ASOS has developed a visual search application that turns the customer's smartphone camera into a discovery tool. The customer can take a picture of a product and the ASOS application, by identifying the shape, color and pattern of the object, can match it with its own inventory and find similar products. Figure 3.3 shows some virtual search applications. For an online-only platform such as ASOS, ('As Screen on Screen') this application is an extremely important e-commerce tool (Boyd 2017). Many retail brands such as John Lewis, Shoes.com, Nordstrom, Hook and Urban Outfitters use visual search to enhance customers' shopping experience. Pinterest, in particular, offers a visual search tool called Lens that lets users take a picture of an item and search on the web or in a Pinterest library for related items.

Figure 3.3. Virtual search applications



ASOS - Source: Boyd, 2017.



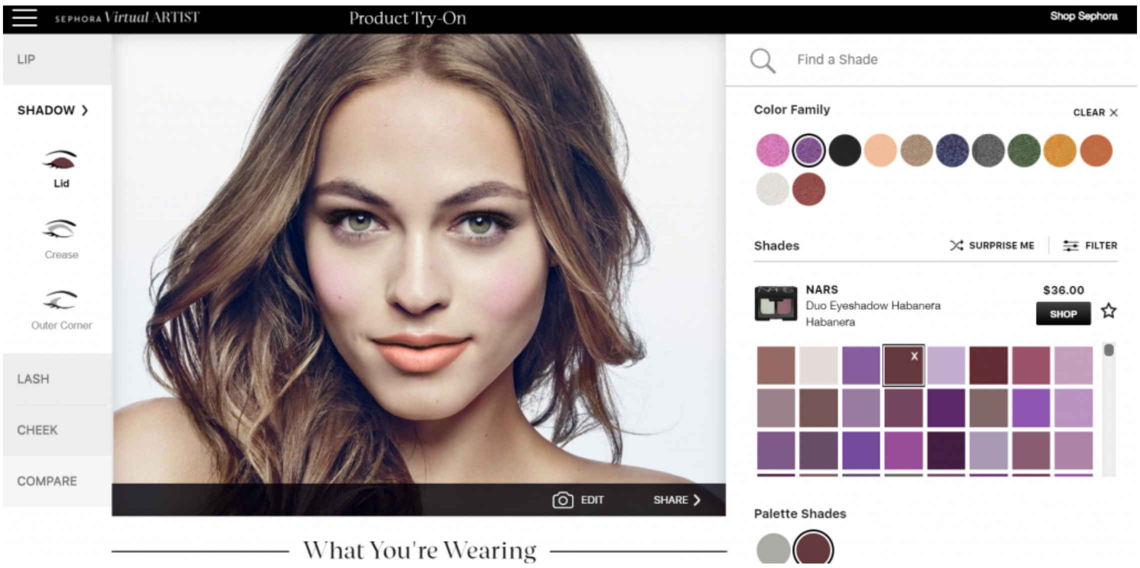
Other brands - Source: Catchoom, 2018.

The granularity of personalization has taken a significant step forward with the Sephora Virtual Artist that combines face-simulation technology based on AI (ModiFace AI technology) with augmented reality to let potential customers try on cosmetic products such as lipsticks, highlighting palettes and eye shadows through the Sephora app or website. Figure 3.4 shows the Sephora Virtual Assistant interface. Sephora has thus leveraged digital transformation to win the pole position as the number one specialty beauty retailer in the world (Rayome 2018).

Subscription services and recommendations engines. The abundance of data provided by digital technologies in retail is enabling strong personalized experiences for customers. One interesting business model that uses data to keep customers captivated is the **subscription model** characterized "by regular and recurring payments for the repeated provision of a good or service" (OECD 2019b p. 70).

This model has been used for delivering newspapers or goods for years, but digital transformation has expanded the range of applications and has generated a variety of subscription models: pay as you go, annual subscription fee paid in one shot, but also different degrees of choice and surprise of what they receive (chosen by the provider or selected in advance by the customer).

Figure 3.4. Sephora Virtual Artist



Source: Boyd, 2017.

Brand subscriptions offer brand products that are kept secret until they arrive at a customers' premises. Causebox is an example.

Targeted subscriptions, before sending products, ask customers a series of questions to understand their product preferences. This model is used by fashion brands such as *Stitch Fix*. Specialized algorithms and personal stylists are used to target the customers using the information collected by the survey and customer feedback. **User-Selected subscriptions.** In this case, the customers are provided with some options and only the products selected are delivered. The customers have still the option to buy or return. A fee is required to pay for the two-way shipping costs if the customers does not buy. **Consumable subscriptions.** This service offers customers the same product used every day (i.e. socks, underwear) at a chosen frequency (once a month).

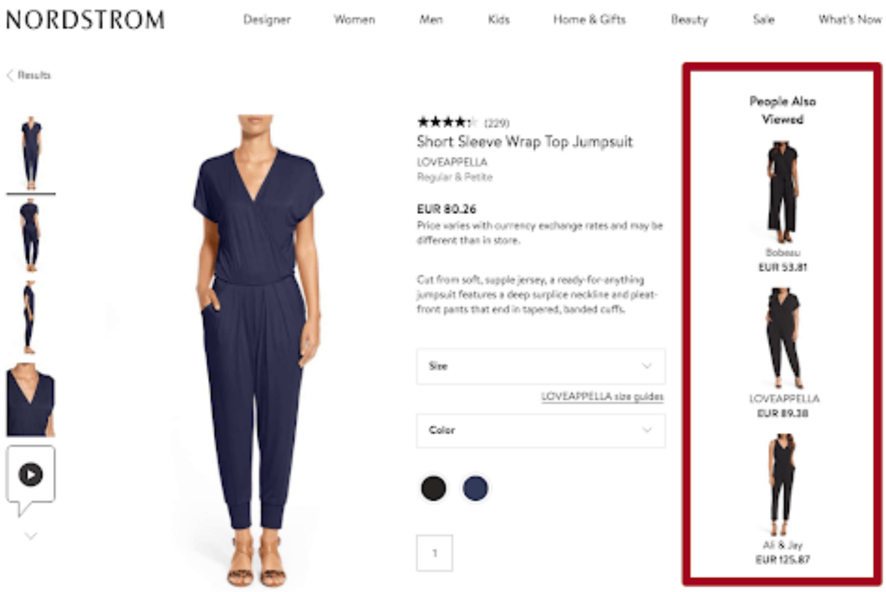
Rental Subscriptions. Rent the Runway (Schwartz (2018) offered women the opportunity to rent clothes. They charge a monthly fee and women have the choice of what they want to rent and afterwards to return it. Rent the Runway customers are also willing to share information about their body type and the fit of the clothing and mention the wearing occasion (Luce 2019 pp. 92-93).

According to Allied Market Research (2017), fashion renting will be worth $1,9 billion in 2023 worldwide. In Italy, a start-up in Milan – DressYouCan – offers this type of service (Giovinazzo 2019).

Merchandising personalization is also achieved by retailers through AI-powered **recommendations engines**. They provide personalized product recommendations based on customer data and quite often they are suggested using expressions such as "*You may also like*" or "*Customers also bought….".* Recommendations engines help users to filter enormous amounts of information they do not need. There are two types of recommendation engines: collaborative filtering and content filtering. The first uses information from a big dataset of customer purchases and other behavior to estimate what customers want. The second one uses customer actions and preferences.

If a customer is visiting a site and buys only black shoes, similar items will be suggested to him during his visit.

Figure 3.5. Recommendations Engines



Source: Catchoom, 2018

Nordstrom, among others, is using recommendations engines. Figure 3.5 shows a Nordstrom recommendation engine in operation. They are similar to what Netflix uses in the media business. These recommendations engines increase the chance of a conversion by suggesting the right item to the customers.

Personal AI Stylist. Having a Personal stylist would represent the top of personalization, but for an average citizen it would be unaffordable. AI is making this possible by creating personal virtual AI stylist. This product is the culmination of the technologies presented so far: natural language processing, natural language understanding, computer visions, neural networks and various types of machine learning. We are already familiar with virtual assistants that use automatic speech recognition such as Apple's Siri, Google's Google Home and Google Assistant and Amazon's Alexa. But the Virtual Style Assistant is a step forward because it emphasizes the use of images, the possibility of taking photos, of having image recognition and visual search capabilities as well as recommendation engines and access to fashion products.

Figure 3.6. Amazon's Echo Look

Source: Amazon Echo Look's website.

Amazon's Echo Look is the most known example of a virtual style assistant (Luce 2019 pp.75-79). Figure 3.7 shows Echo Look. This hands-free camera is intended to give users feedback on their outfit selection. Using voice commands, Echo look takes a picture of the outfit and gives suggestions on the merit of it, based on trends and professional stylist opinions. It can also make personalized recommendations for better combinations of items based on the outfits available in the user's personal wardrobe or items available on Amazon.

This service is offered by the Style Check feature (see Figure 3.8). Different attitudes towards choosing clothing, cultural differences among nations and concerns about privacy in the bedroom make it difficult to estimate the real rate of adoption of this type of products.

Figure 3.7

Source: Amazon Echo Look's website.

Customer experience enhancement in-store. Digital technologies are also enhancing customer experience in stores. Fashion luxury brands are using smart mirror technologies in combination with their physical stores.

Figure 3.8. Memo Mi's smart mirror

Source: Kothari, 2015.

A smart mirror is “a two-way mirror with an electronic display behind it. They are computers enabled by a full stack of technology, from hardware with depth sensing to software equipped with advanced computer vision algorithms” (Luce 2019 p. 39).

The mirrors let users not only see how they look in a garment with different colors, but also to change type of clothing and make side-by-side comparisons of different outfits. In this way, the shopping experience becomes much more enjoyable and easier. Furthermore, these mirrors also let customers share images with people outside the store, bringing home the images or videos, buy the items without waiting in line at cash register. Smart mirrors also help retailers to bridge the gap between online commerce and brick-and-mortar stores.

This is what iMirror does, providing an immersive in-store experience that lets customers discover personalized offerings (see Figure 3. 10).

Figure 3.9. iMirror

Source: iMirror website

Figure 3.10

Source: Macy's on call website.

Macy's also is complementing its physical stores offering with an in-store smartphone-based helper powered by IBM Watson AI technology – **Macy's on call** - (see Figure 3.11) that lets customers talk with digital assistants when they are in the store.

That AI technology can power better offline engagement is demonstrated by **Farfetch's Store of the Future.** It features automatic customer recognition as the shopper arrives at the store and tools such as **Connected Clothing Racks**, **Interactive Holograms** and **Connected Mirrors.** Connected clothing racks offer a combination of RFID and ultrasounds. RFID recognizes the product and ultrasounds recognize the movement. Therefore, when a customer picks up garments from the rack, the image of the clothes is sent to the app of the customers creating an in-store wish list. Interactive holograms let customers create and order customized shoes in different colors of leather. Connected mirrors let them choose different sizes and colors of clothing, to request the delivery of these items to the fitting room and to pay without leaving the fitting room (B.D.C. 2019)

3.3.2 Predictive analytics and AI for trend and demand forecasting

The phrase 'predictive analytics' includes a group of techniques from statistics to machine learning that uses historical data to make predictions using models. A model in predictive analytics is an algorithm that uses the past to predict the future. In fashion, one of the most common applications of predictive analytics is the **size recommendation** to match a customer with the size that will best fit them for a given garment (Luce 2019 pp.109-11; 160-161).

According to a Body Labs 2016 retail survey, $62.4 billion worth of apparel merchandise and footwear are returned each year because of improper sizing or fit (Ilyashov 2016).

Fit Analytics, based on the information supplied by the customers (height, weight, age and fit preference) through its interface Fit Finder, returns a best-fit recommendation. Fit Finder powers more than 500 million recommendations every month and is used by many fashion brands such as The North Face, ASOS, Tommy Hilfiger but also start-ups such as Amaro, the hottest digital native brand In Brazil.

Fit Analytics helped Amaro in increasing its conversion rate by 2% and reducing its return rate by 4% (FitAnalytics.com). But predictive analytics could also be helpful to:

- Find out which customers are more likely to make a purchase, and which are likely to leave the platform (analyzing the number of visits to product pages, frequency of newsletter opens, etc.)
- Fight frauds and detect suspicious transactions.

Predictive analytics also offer demand forecasting for consumer goods and services. This is particularly critical for the fashion industry because accurate forecasting can reduce inventories and product waste. Deep-learning algorithms, based on neural networks, offer considerable help in demand forecasting.

For instance, **Long-short -term memory** (LSTM) models are used for time-series forecasting or a **transfer learning model** helpful for forecasting using small data sets. AI could also be particularly helpful in **tracking fashion trends.** While it could be particularly difficult for human beings to answer questions such as "how many people wore white t-shirts in New York today compared to two years ago?", for AI it is easy to compare millions of images from different social media and provide an answer (Thomassey et. al., 2018).

3.3.3 Product, inventory and supply chain management

Despite the application of technology and brainpower to improving supply chains, the performance of many supply chains has never been worse. In general, due to the inability of predicting demand, supply chains experience an excess of some products and a shortage of some others (Fisher 1997).

The fashion industry's supply chain is no exception. To manage a supply chain effectively it is essential to understand the nature of the demand for the products one's company supplies. According to Fischer (1997) and as shown in Table 3.1, product demand depends on many aspects such as product life cycle, product variety and other factors and can fall into one of two categories: primary functional or primary innovative. Each category implies different kinds of supply chain. Demand forecasting for the fashion industry is becoming particularly challenging due to the changing nature of the industry itself. Indeed, the product life cycle is becoming shorter ("Short Fashion").

Zara is a case in point. Zara's customers "soon learned from experience that there would be something new in Zara shops every week and that 70% of the product range would change every two weeks" (Pich et al., 2002).

Therefore, correctly predicting the amount of inventory to manufacture and manage it, is particularly important to avoid decreasing margins when products are discounted or complete losses when the products are unsold. For instance, in March 2018 H&M reported a drop in sales for the last quarter of 2017 and told shareholders that "it was sitting on a huge pile of unsold clothes — $4.3 billion worth of inventory" (Rudenko 2018).

Table 3.1

Functional Versus Innovative Products: Differences in Demand

	Functional (Predictable Demand)	**Innovative** (Unpredictable Demand)
Aspects of Demand		
Product life cycle	more than 2 years	3 months to 1 year
Contribution margin*	5% to 20%	20% to 60%
Product variety	low (10 to 20 variants per category)	high (often millions of variants per category)
Average margin of error in the forecast at the time production is committed	10%	40% to 100%
Average stockout rate	1% to 2%	10% to 40%
Average forced end-of-season markdown as percentage of full price	0%	10% to 25%
Lead time required for made-to-order products	6 months to 1 year	1 day to 2 weeks

* The contribution margin equals price minus variable cost divided by price and is expressed as a percentage.

Source: Fischer, 1997.

For this reason, applications of AI to supply chain management are becoming widespread in the fashion industry. These applications range from the use of machine learning to trend and demand forecasting and inventory management. Using AI tools for demand forecasting is enabling retailers to reduce forecasting errors by up to 50% and simultaneously reduce inventory by 20% to 50% (Standish et al., 2018)

AI is used by retailers to **increase stock turnover** by taking into account the 'need' to sell older stock as soon as possible (Kellet 2018).

Farfetch, the world's top luxury online marketplace, is promoting AI among Farfetch's partners (1,500 boutiques and over 200 brands) to **improve supply chain visibility** by linking "their online inventory with inventory in their physical stores and deliver services like click-and-collect and in-store returns" (Intelligence Node 2017). Fashion retailers are also using RFID for real-time inventory tracking and IoT and robotics to enhance inventory management and optimize the supply chain.

Otto, the largest online retailer of fashion and lifestyle products for end-consumers in Germany, is using a deep learning algorithm to predict, with 90% of accuracy, what customers will buy before they place the order. This forecasting capacity has enabled Otto to introduce a stock management system that automatically purchases goods from third-party brands (The Economist 2017).

Overall, the use of AI in supply chain management also helps in reducing the ‘click to ship’ cycle time and the dropout rate (Weiß 2016).

Finally, AI is also used for warehouse management and operational procurement. Indeed, improvements in AI and navigation technologies are letting automated guided vehicles (AGVs) move materials between buildings. Until recently, they needed physical path guiding mechanisms such as wires or tracks. Furthermore, chatbots can be used in operational procurement because they reduce transaction costs and sales cycle time (Bharadwaj 2019).

3.3.4 AI for operations automation

According to Luce (2019), the word robot is quite often encountered in the fashion industry. However, there is not a unique definition of it. For some, “*it is it simple enough to describe a robot as a programmable machine that carries out complex actions. For others, a robot is really the physical embodiment of artificial intelligence that takes action in the physical world*” (Luce 2019 p.170).

In the fashion industry, industrial robots are used for sewing and for supply chain management. In factories, robots are used for sewing. This is the case of SoftWear Automation, an Atlanta based robotics company focused on robots for sewing. According to its CEO, using sewing robots has significant advantages in cost reduction, reshoring production, reducing waste and therefore environmental impact and increasing manufacturing flexibility (Luce 2019). But, beyond the factory, robots in the fashion industry are used in the warehouse for picking and packing procedures. Kiva systems are an example of robotic automation in warehousing. Companies such as Saks Fifth Avenue, The Gap, and the Gilt Group all use Kiva Systems. Kiva was acquired by Amazon in 2012 and renamed Amazon Robotics. Nike, for instance, is an investor in GRABIT, that provides electro adhesion-based gripping products for robotics and material handling applications in logistics (Segura 2018).

Robots are also used to improve customer service: Zara, for instance, uses robots to speed up the in-store pick-up process. Customers that have placed online orders, can scan or enter a code in the shop and the robots search for the order and take it to a drop box where customers can pick it up (Musariri 2018).

3.3.5 Artificial Intelligence for the design process

An area of growing interest for the fashion industry is the use of AI for fashion design. On 6 November 2018, Yoox, the leading Italian e-commerce company, presented ***8 by Yoox***, the first fashion collection designed using AI. A software assembles images and texts collected from social networks and articles from online magazines; then an AI engine collects predictive indicators on fashion and purchasing trends, revenue data from Yoox websites and customer opinions to generate a dynamic mood board used by human designers to create garments and accessories (Mazza 2018; Marchetti 2019). Amazon in 2017 announced the possibility of training a generative adversarial network (GAN) from the family of generative models, to design garments. These models can create images of clothing and can be helpful as starting points for designers. Amazon's elementary AI fashion designer "*learns about a particular style of fashion from images and can generate new items in similar styles from scratch*" (Ramirez 2018).

IBM joined efforts with Tommy Hilfiger and the Fashion Institute of Technology (FIT) Infor Design and Tech Lab on a project called **Reimagine Retail** to show how "*AI can assist design teams by enhancing and reducing overall lead times, and expand their creative discovery by analyzing and remembering insights from thousands of images and videos using computer vision. Also, designers can detect how they can integrate trending colors, key patterns, and style*" (Segura 2018).

Shimmy Technologies, a Brooklyn apparel and tech startup, has incorporated artificial intelligence to help speed up the swimwear apparel design process. Swimwear is notoriously difficult to measure, and tailors need to take measures multiple times. Shimmy partnered with IBM's Watson AI to develop a system such that when tailors give a measurement to the computer, it creates a 3D model of a design. Using AI, Shimmy cut designers' worktime by 20% (Ramirez 2018).

Stitch Fix, the online styling service company with $1 billion in revenue, uses "*genetic algorithms*" to design new apparel styles for its clothing. Using customer feedback for items such as color, sleeve style and hem length, it creates "*new styles by recombining attributes from existing styles and possibly mutating them slightly*". These new styles are then evaluated and approved by human stylists before they reach the clients (Ramirez 2018).

Overall, machine learning and computer vision technologies can be used to design the new 'must have' fashion products that match the continuous evolution of customer preferences (Wong 2019).

A particular effort is devoted to the creation of electronic textiles known as Smart Fabrics (see Figure 3.12) that incorporate digital components to offer a variety of benefits to users from customized fits to weather adaptability, release of medication, temperature regulation, heart rate monitoring, muscle vibration and even self-cleaning (Bagaar 2018; Intelistyle 2018).

Figure 3.11. Smart Fabrics

Source: Intelistyle, 2018**.**

NEUE, a Swedish fashion-tech company, that had developed a chip with sensors and processors that enabled the control of electro-luminescent fabric, worked with New York's Fashion Institute of Technology to design a garment and an accessory shown on the red carpet at the Harper's Bazaar Icons event (Cadogan 2018).

Smart Textiles are very closely linked to IoT developments. A particularly interesting application of smart fashion techniques is the **Live: Scape BLOOM** (see Figure 3.13) an "*IoT connected dress whose floral embellishment changes mode over time in response to real-time, meteorological data streams. Live: scape BLOOM uses conventional textile fabrics, jewellery beads and trims, electronics components, a WIFI development kit, servo-motors and custom software*" (McMillan 2019).

This dress shows the opportunities for wearable, IoT connected shapes as smart fashion. Nano photonics for artificial intelligence can extend the concept to future applications for health, communications and lifestyle.

Figure 3.12 Live: Scape BLOOM

3.3.6 AI for sustainable fashion

The fashion industry is known to be pollutive, to require raw materials such as leather in excess of global supply, to consume an enormous quantity of water to dye fabric and to produce a great waste of fabric due to current trends of fast fashion: "*Every week a new trend, every month a new wardrobe. From 2 seasons a year, fashion conglomerates are pushing up to 6 seasons a year to their customers as if they were inevitable*" (BAGAAR 2018).

According to Paul Dillinger, Vice President and Head of Global Product Innovation and Premium Collection Design at Levi Strauss & Co "*six out of 10 garments we produce end up in a landfill or are incinerated within the first year of production*" (Wall 2018).

To be more sustainable the fashion industry should start from new types of fabric and material innovation and biotechnology could play a great role. Shrilk, a material made from discarded shrimp shells and proteins from silk, is very strong but much lighter than aluminum; materials like Viscose, Tencel or Lyocell are all biodegradable and much more economical in their use of energy and water compared to cotton (BAGAAR 2018).

Furthermore, high end brands are starting to produce sustainable garments using recycled fabrics or organic materials such as orange peels, mushrooms or even algae (Ricci 2018).

Finally, AI can guide the fashion industry towards a more sustainable framework, optimizing retailers' business models and making them less wasteful through: 1) **better demand and sales forecasting** (it is estimated that H&M held $4.3 billion in unsold merchandise in 2017) that will minimize waste products through reduction of over-production and an optimal allocation of merchandising; 2) **more effective and transparent supply chain management.** Besides better supply chain management, AI can also help in providing more transparency in the supply chain, offering information on what raw materials are used and where companies are sourcing their labor.

An open question is also the role that blockchain technology integrated with AI could play in tracking the origin of manufactured goods; 3) **personalized shopping experience**: knowing more about customer preferences will make it possible to reduce waste and the number of unsold goods (de Freitas 2018).

4. Survey on Machine Learning & Artificial Intelligence Use in the Fashion Industry

4.1 A survey on the use of AI in the Fashion Industry

In the previous chapter we discussed the major applications of AI for the fashion industry on the basis of current literature and desk research.

Table 4.1 shows in greater detail a matrix of the technologies and solutions involved in the major applications of AI to the industry. However, we decided to also test in the field, through an ad hoc survey, the knowledge, awareness and utilization of AI in the fashion industry.

The sample was created using industry contacts. Potential respondents were contacted by email and the survey was handled using the program Google Forms. The following nine companies were contacted: Amaro, Amazon, Deloitte DCM Fashion & Luxury, MaxMara, Miroglio Group, Yoox, Zalando, Zalora, Zara. The questionnaires were filled in between May and June 2019.

The questionnaire was designed on the basis of the following surveys:

1) Community Innovation Survey
2) Rilevazione sulle Tecnologie ICT nelle imprese, ISTAT (2018)
3) Marketest (2019)
4) Canadian Survey of Advanced Technology, Statistics Canada (2014)

Furthermore, for the specific questions on AI, the matrix of Applications-Technologies Processes presented in Table 4.1. was used.

The questionnaire was structured in 4 sections:

A. Anagraphics
B. Machine learning (ML) and Artificial Intelligence (AI) Applications
C. Investments in ML and AI
D. Impact of ML and AI on labour force

Table 4.1. Matrix Artificial Intelligence Applications – Technologies and Processes

	ARTIFICIAL INTELLIGENCE APPLICATIONS							
	Customer Service	Customer Experience enhancement	In-store experience enhancement	Product, Inventory and Supply Chain Management	Trends and demand Forecasting	Design Process	Operations Automation	Sustainability
TECHNOLOGIES AND PROCESSES	Virtual Personal Assistants	Social Analytics	Smart Mirrors	Link online inventory with inventory in physical stores	Spot trends and produce new variations of garment design	Visual Searching	Robots for Sewing	Recycled fabrics
	Virtual Customer Assistants	Cognitive Reasoning	Augmented reality	Click-and-collect and in-store returns	Using of Big data for price planning	A robot meets the designer	Robots in warehouses for picking and packing procedures	
	Real time communication via chatbots or touch screens	CRM Analytics	Digital Signage and Shelves	Reduce click to ship cycle time	AI powered tools for demand forecasting	Using AI Tools to crunch profiles completed by clients and offering recommendations to clients	Use of AI to enable autonomus decision-making, from observing and strategizing to deciding	
		Customer Journey and Personal Analytics	Cognitive reasoning	Reduce dropout rate	AI for customers purchase prediction	Using AI to reduce overall lead times		
		Social Commerce	RFID-clothing racks	Shrinking the supply chain	Predictive Analytics for size recommendations	Design Inspiration from Generative Networks (such as Generative Adversarial Networks -GANs)		
		VPA-Enabled Wireless Speakers	Virtual reality applications	Real-time inventory tracking (e.g. with RFID)	Data Mining	Using 3D design models		
		Through Image analytics	In store smartphone-based helper powered by AI	Warehouse management	Prophet			
		Computer Generated design	Automatic customer recognition as the shopper enter the store	Operational procurement				
		Virtual Reality (DressingRoom)						
		Tailored recommendations						
		Personal AI Stylist (Amazon Echo Look)						
		AI Voice Commerce						
		Rental Suscription services:send customers boxes of clothing to keep or return						
		Brand Subscription						
		Targeted Subscription						
		User-selected subscription						
		Consumable Subscriptions: users receive the same product at a set frequency for items they use every day						
		Applications that use AI to help people define thier personal style by recommending outfits from their own closets.						
		Visual Recognition						
		Reccomendation engines such as Fit Finder						

Source: self-elaboration.

The anagraphics part contains basic information such as the name, location, number of employees and revenue of the company. Section B is focused on gathering information on the AI applications used by the company. It starts with asking a definition of Artificial Intelligence according to Table 4.2.

Table 4.2

How would you define 'Artificial Intelligence (AI)'?
1. Artificial Intelligence is a machine that can work and react like a human
2. Artificial Intelligence is a system, consisting of a series of algorithms, which can learn from constant input
3. Artificial Intelligence is a system that can learn and develop on its own
4. Other

Then, it asks YES or NO answers to the macro questions from Table 4.3 with subsequent additional questions based on Table 4.1.

Table 4.3

Does your enterprise use ML/AI for customer service?
Does your enterprise use ML/AI for customer experience enhancement?
Does your enterprise use ML/AI for in-store experience enhancement?
Does your enterprise use ML/AI for product, inventory and supply chain management?
Does your enterprise use ML/AI for trend and demand forecasting?
Does your enterprise use ML/AI for price optimization?
Does your enterprise use ML/AI for Design Process?
Does your enterprise use ML/AI for operation automation?
Does your enterprise use ML/AI for sustainable fashion?

Section C concerns investments in ML/AI and collects insights into how much companies have already invested in 2018 and will invest in AI in the next two to three years and how they acquire or integrate AI technologies. The last section is devoted to investigating the impact of ML/AI on the labor force, in terms of current or future job losses, new skills training and specialized AI recruitment. The survey ends with a question related to the support of the company for the 'AI for good' approach: "*On a scale from 1 to 5 how would your enterprise consider the support to an 'AI for good' approach to algorithm design, customer privacy protection and loyal relationship with customers?*" The full questionnaire is available in the appendix.

4.2 The results of section B

The response rate to the survey was around 60% and the results, although based on a small sample, appear quite coherent and representative of the approach of the sampled companies to AI. First, 60% of the companies that answered the survey defined AI as "*a system, consisting of a series of algorithms, which can learn from constant input*".

Clearly, the majority of respondents have a precise idea of what AI is and understand that AI is based on algorithms but is more than that and in particular that it learns from a continuous data input and manipulation. The remaining 40% were split equally in their answers between the more 'extreme' definitions: "*Artificial Intelligence is a machine that can work and react like a human*" and "*Artificial Intelligence is a system that can learn and develop on its own*". Table 4.4 summarizes the results from the answers to the macro questions of section B of the survey.

These results clearly show that the great majority of companies (80%) in the survey use AI for enhancement of customer service and customer experience online. Instead, only 20% declare using AI for in-store customer experience enhancement showing that the majority of the companies that answered the survey only have an on-line presence. AI is used by all firms (100%) to improve trend and demand forecasting. Another extensively used application of AI (80% of positive answers) is for product, inventory and supply chain management.

Table 4.4

Questions	YES	NO
Does your enterprise use ML/AI for customer service?	80%	20%
Does your enterprise use ML/AI for customer experience enhancement?	80%	20%
Does your enterprise use ML/AI for in-store experience enhancement?	20%	80%
Does your enterprise use ML/AI for product, inventory and supply chain management?	80%	20%
Does your enterprise use ML/AI for trend and demand forecasting?	100%	0%
Does your enterprise use ML/AI for price optimization?	60%	40%
Does your enterprise use ML/AI for Design Process?	60%	40%
Does your enterprise use ML/AI for operation automation?	40%	60%
Does your enterprise use ML/AI for sustainable fashion?	0%	100%

Furthermore, 60% of the companies responding to the survey stated they use AI for price optimization, design process and operation automation. This is still significant, but a lower percentage compared to the percentage of answers related to customer experiences, which can probably be explained by the different role played by these companies in the fashion value chain. A bit surprising is the result related to the question on the use of AI for sustainable fashion. Indeed, all companies answered this question in the negative.

There are two possible explanations for this result. First, that the question was not properly understood. Indeed, while the companies responded positively to all questions related to means for reducing waste (for instance through better demand and trend forecasting with consequent reduction of over-production or through a more efficient supply chain management) they all denied the use of AI for sustainable fashion. Second, that the use of AI for sustainable fashion is still at such an embryonic stage for all these companies that in practice it is still totally irrelevant.

4.2.1 A more granular approach

After this view at glance of the main results of section B, it can be helpful to give a more granular look at some of the specific answers given to the questions following the YES or NO macro questions.

We will focus only on those questions answered by more than 50% of respondents. Among the companies that answered positively to the question on the use of AI for customer experience enhancement, 100% said that they do that using CRM analytics, 75% through image analytics, 75% through visual recognition, 75% using recommendation engines such as FitFinder.

On the contrary, no one mentioned the use of subscription-type services (such as sending customers boxes of clothing to keep or return or brand or user-selected subscription). And only very few are using Personal AI Stylist, dressing room and AI voice commerce. Regarding the use of AI for products, inventory and supply chain management, 75% of the respondents declared that they use AI for “real time inventory tracking and warehouse management” as a means to achieve this goal. When it comes to the use of AI for demand and trend forecasting, 100% of the respondents declared that they use AI-powered tools for demand forecasting and 75% use AI for churn prediction. The use of Big Data for price planning is mentioned by 60% of respondents as way to practice price optimization.

4.3 The results of section C

This section is devoted to exploring the level of investment in AI and the way in which companies acquire AI technologies. The quantitative questions on the current and future level of investment on AI were considered by respondents in a mixed way. Some mentioned their level of investment in the order of millions of euros, some others considered these questions very confidential and therefore did not answer at all. Therefore, we cannot consider these answers reliable. Instead, the answers to the block of questions on "*How does your enterprise acquire or integrate AI technologies (e.g. equipment or software*)?" shown in Table 4.5, present some interesting results.

Table 4.5

By sharing agreement	40%
By purchasing off-the-shelf advanced technology (e.g. equipment or software)	40%
By leasing off-the-shelf advanced technology (e.g. equipment or software)	40%
By licensing advanced technology	20%
By developing new advanced technologies (either alone or in conjunction with others)	60%
Through merger or acquisition of another enterprise with advanced technologies	20%
By partnering with academic or research organizations	80%
By creating start-ups	0%
Other: open source	20%

The results clearly show that the companies surveyed prefer to acquire AI technologies through partnering with academic or research organizations (80%) or by developing new advanced technologies by themselves or in conjunction with others (60%). Merger or acquisition of other companies with advanced technologies or creation of start-ups are definitely less common (only 20% of the cases for M/A) or even totally absent, as in the case of start-ups (0%).

These results are only partially aligned with the OECD 2019d analysis on AI investments worldwide that describes the share of corporate internal investment in AI as 70% of the total, with the remaining 20% in AI investment in start-ups and 10% in acquisition. The size of the companies that did not answer the survey probably explains this different result.

4.4 The results of section D

The last section of the survey is concerned with the impact of AI on the labor force. The overall results show that the companies believe that the current impact of AI on labor force in terms of job losses is not strong. Indeed, it is weak for 60% of respondents and mild for the remaining 40%. Looking ahead to the next 3 years, still 60 % believe that the impact will be weak, 20% mild and only 20% strong. When the companies were asked if their employees had received specific training on AI in 2017 and 2018, they all answered positively (100%).

The same is true for the recruitment of people with specialist AI skills during the same period. Answers to the final question, asking for an evaluation of the support of the companies for the 'AI for good' approach, reveal that all the companies believe strongly in this approach. Indeed, 60% declare that it is very important, 20% important and an additional 20% between important and very important.

4.5 Conclusions

The results of the survey confirm the findings of the analysis of the literature and the desk research of Chapter Three.

AI is starting to be used extensively in the fashion industry, in particular to improve customer experience both online and off. Trend forecasting, supply chain management and price optimizations are also widely employed applications in the industry. Additional and more tailored applications are exploited by some companies of a larger size or with also a particularly strong presence in the online or off-line markets. Particularly interesting are the results from section D that show that the impact on the labor force from the use of AI is not seen as threat to the employment by the majority of respondents. Furthermore, all companies express a very positive attitude towards the 'AI for Good' approach to algorithm design, customer privacy protection and loyal relationship with customers.

5. Conclusions

5.1 Technology and Fashion Industry

This research has shown that technology has always played an important role in fashion. Yet, it is with the diffusion of digital technologies and the wealth of data created by these technologies – the digital transformation – that the fashion industry started a more profound and faster transformation that is changing the way in which customers shop and interact with products and brands. At the same time, companies are adopting these technologies to manage their own supply chain better or are using real-time data and analytics to forecast demand better and optimize pricing.

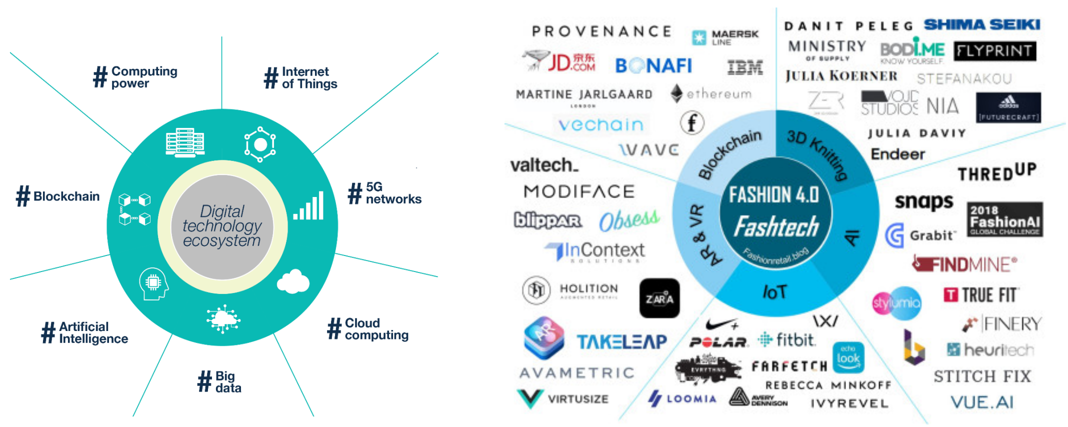
The "datafication of fashion" – the capacity to create digital data in relation to fashion products and production processes – that is making the fashion sector both an important consumer and supplier of data, which proves very useful in informing production decisions, improving planning and logistics and customizing products. Moreover, fashion data are also used to feed into the rest of the value chain: wholesalers, retailers, finance and product input sectors such as textiles and leather.

5.2 The Fashtech ecosystem

The digital transformation is nurtured by an ecosystem of interdependent digital technologies that through interactions with the fashion industry, as shown in Figure 5.1, is generating a Fashtech ecosystem, a wealth of companies and startups that are capitalizing on the properties of specific technologies to disrupt the fashion industry and also change our daily life (Segura 2018a).

Figure 5.1. From the ecosystem of digital technologies to the Fashtech ecosystem

Ecosystem of digital technologies → Fashtech ecosystem



Source: OECD (2019) and Segura (2018a).

Companies such as Farfetch, that sells products from over 700 boutiques and brands from around the world through an online fashion retail platform, are using **IoT** to blend online and physical stores and give customers a new and original experience through the **Store of the Future** (Segura 2018b). **Zara** is heavily betting on experience in the digital and omnichannel era. For instance, the chain recently launched an **augmented reality shopping app** that brings to life models such as Léa Julian and Fran Summers for 7- to 12-second sequences that help customers in making their choices of garments (Segura 2018c).

ADIDAS is using **3D printing** to create and customize soles for shoes, using Futurecraft 4D technology with the help of Carbon, a company that uses 3D printing. The midsole is formed using Carbon's "Digital Light Synthesis" technique, which uses oxygen and light to form the sole, allowing for a higher quality product faster than with traditional 3D printing. Also New Balance and Under Armour are experimenting with 3D printing manufacturing (Segura 2018d).

5.3 Artificial Intelligence and the fashion industry

AI, as an overarching category that includes several tools and techniques and application areas, is contributing to the major changes and disruption of the fashion industry. According to McKinsey&Company (2018), 75% of retailers plan to invest in artificial intelligence during 2018 and 2019 and artificial intelligence in the fashion industry will be used to "*reinvent design, merchandising and marketing, but also to deliver significant speed, cost and flexibility improvement across the fashion supply chain"*.

But AI also has the potential to completely disrupt the fashion industry, not only because of new business models, new ways of production, but also on account of the impact on the people employed in the fashion industry and on their jobs.

Artificial intelligence solutions such as AI smart assistants or image search are helping companies such as **ASOS** or **Nike** or **Sephora** to enhance customer service and online customer experience.

The abundance of data provided by digital technologies in retail is making highly personalized experiences possible, such as subscription services – used by companies like **Stitch Fix** – and recommendation engines that are allowing the developing of completely new business models – for instance the one used by **Rent the Runway,** which offers women the opportunity to rent clothes and is fostering changes in customer because "*Rent the Runway wants to lend you your look*" (Schwartz 2018).

Recommendation engines are contributing to offering product personalization based on customer data and previous purchases to companies like **Nordstrom**; companies like **Amazon** are even promoting a personal **virtual AI stylist** that, combining many AI technologies such as natural language processing and understanding, computer visions and neural networks and machine learning, offers services like **Style Check** that makes personalized clothing recommendations based on the outfits available in the user's personal wardrobe.

But AI is also enhancing the in-store customer experience through smart mirror technologies and fitting rooms of the future or digital assistants like **Macy's on call,** when customers are in the store. AI is also making better trend and demand forecasting possible, which is fueling applications such as **Fit Finder** that offers size recommendations and drastically reduces customer return rates because of improper sizing or fit. North Face, Tommy Hilfiger and other brands use this application. But AI is also used to improve product, inventory and supply chain management, for operations automation and for design process. Companies like Yoox have used AI to design fashion collections (8 by Yoox) or others like Shimmy Technologies to speed up swimwear apparel design.

5.4 A Survey on AI use in the fashion Industry

This research has also tested the use of AI in the fashion industry through a survey run among a selected group of fashion companies. Although the sample is small (9 companies involved) the results are quite interesting and confirm the findings of the literature review and the desk research as outlined in Chapter 3.

Table 5.1

Questions	YES	NO
Does your enterprise use ML/AI for customer service?	80%	20%
Does your enterprise use ML/AI for customer experience enhancement?	80%	20%
Does your enterprise use ML/AI for in-store experience enhancement?	20%	80%
Does your enterprise use ML/AI for product, inventory and supply chain management?	80%	20%
Does your enterprise use ML/AI for trend and demand forecasting?	100%	0%
Does your enterprise use ML/AI for price optimization?	60%	40%
Does your enterprise use ML/AI for Design Process?	60%	40%
Does your enterprise use ML/AI for operation automation?	40%	60%
Does your enterprise use ML/AI for sustainable fashion?	0%	100%

Table 5.1 summarizes the results from the section of the survey on the use of AI and shows that the AI is extensively used among the survey's respondents to enhance customer service and customer experience online, to optimize product and supply chain management and for trend and demand forecasting. Other applications are also quite common among the companies surveyed.

5.5 Long run impact of AI: towards a complementarity between man and machine?

What is also particularly interesting in the survey results is the section on the impact of AI on the labor force. The survey shows that the companies believe that the current impact of AI on the labor force in terms of job losses is not strong (weak for 60% of the respondents and mild for the remaining 40%). Looking at the next 3 years, 60% still believe that the impact will be weak and the remaining 40% is split between 20% mild and 20% strong. Companies also indicate being aware of the need to re-train their employees: all companies have done that in 2017 and 2018 while also hiring people with specialist AI skills in the same period.

This result probably signals that the fashion industry, although definitely disrupted by the AI revolution, is learning how to integrate AI technologies in the production process and marketing and operations management. The case in point is the use of AI for product design. AI is seen by many as a complement to the work of the fashion designers, an opportunity and not a threat: it helps in setting the stage for analyzing trends, revenue data and customer experiences to generate dynamic mood boards that human designers can use to create garments and accessories; or the use of GANs can be helpful for creating images of clothes that can be used as starting points for designers.

But, the use of AI in the creation of fashion designs is also raising specific copyright questions: who owns the rights to machine-made works?

In the USA, under US Law, there is no clear copyright protection for fashion designs made using AI. In other countries outside the US, such as the UK, India, Hong Kong, Ireland and New Zealand, the situation is more flexible and there are regulations that “*give authorship to the person who programs the AI*” (Ford et al., 2018). This discussion shows that many questions still need to be addressed, but that blending artificial intelligence and human expertise in the fashion industry appears to be a promising avenue. But, to pursue this path it is also necessary to support the ‘AI for good’ approach, i.e. to manage the diffusion of AI technologies properly so as to guarantee that “AI systems will be human-centric, with the goal of improving individual and societal well-being, and worthy of our trust” (EC 2019a).

The companies that answered the survey appear highly aware of such a need and overwhelmingly decided to support the ‘AI for good’ approach to algorithm design, customer privacy protection and loyalty relationships with customers. The use of AI in the fashion industry suggests that we should not see the future of work in its replacement or displacement by technology but in the complementarity of humans and machines. Smarter machines and smarter people can complement each other to create a plethora of customized products and services: the world of new artisans. The fashion industry can lead the way in this process.

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APPENDIX

Survey on Machine Learning & Artificial Intelligence Use in the Fashion Industry

The objective of this survey is understanding how digital transformation is changing the Fashion sector, and in particular, collect information on the use of Machine Learning (ML) and Artificial Intelligence (AI) in the Fashion industry. Your responses will be anonymised and only used on an aggregate level as part of the case description. The data will be kept confidential and used only for the research purposes of a BA Thesis.

Section A – ANAGRAPHICS

1. **Address**

2. Number of employees in 2018:

3. Total Revenue in 2018

Section B – ML & AI Applications

4. How would you define 'Artificial Intelligence' (AI)?

We are looking for your personal opinion. There is no right answer for the purpose of this question

Artificial intelligence is a machine that can work and react like a human

Artificial intelligence is a system, consisting of a series of algorithms, which can learn from constant input

Artificial intelligence is a system that can learn and develop on its own

Other:

5. Does your enterprise use ML/AI for customer service?

YES

NO

6. If Yes, please select all that apply

Virtual Personal Assistants

Virtual Customer Assistants

Real time communication via chatbots or touch screen

Other:

7. Does your enterprise use ML/AI for customer experience enhancement?

YES

NO

8. If, Yes does your enterprise use:

Social Analytics

Cognitive Reasoning

CRM Analytics

Customer journey and personal analytics

Social Commerce

VPA-Enabled Wireless Speakers

Through Image analytics

Computer generated design

Virtual reality (Dressing Room)

Tailored recommendations

Personal AI Stylist

AI Voice Commerce

Rental subscription services: send customers boxes of clothing to keep or return

Brand subscription

Targeted subscription

User-selected subscription

Consumable subscription: receive the same product at a set frequency for item they use every day

AI applications recommending users the outfits from their own closets Visual Recognition

Recommendation engines such as Fit Finder

Other:

9. Does your enterprise use ML/AI for in-store experience enhancement?

YES

NO

10. If Yes, does your enterprise use for in-store experience enhancement:

Smart mirrors

Augmented reality

Digital Signage and shelves

Cognitive reasoning

RFID-clothing racks

Virtual reality application

In store smartphone-based helper powered by AI

Automatic customer recognition as the shopper enters the store

Other:

11. Does your enterprise use ML/AI for product, inventory and supply chain management?

YES

NO

12. If Yes, does your enterprise use ML/AI to:

Link online inventory with inventory in physical stores

Click-and-collect and in store returns

Reduce click to ship cycle time

Reduce dropout rate

Shrinking the supply chain

Real-time inventory tracking (e.g. with RFID)

Warehouse management

Operational procurement

Other:

13. Does your enterprise use ML/AI for trend and demand forecasting?

YES

NO

14. If Yes, does your enterprise use:

AI to Spot trends and produce new variations of garment design

ML/AI powered tools for demand forecasting

ML/AI for churn prediction

Predictive analytics for size recommendations

Data Mining

Prophet

Other:

15. Does your enterprise use ML/AI for price optimization?

YES

NO

16. If Yes, does your enterprise use Big Data for price planning?

YES

NO

17. Does your enterprise use ML/AI for Design Process?

YES

NO

18. If Yes, does your enterprise use:

3D design models

Visual searching

AI tools to crunch profiles completed by clients to offer recommendations to clients

AI to reduce overall lead times

Design inspiration from Generative Networks (such as Generative Adversarial Networks- GANs)

Other:

19. Does your enterprise use ML/AI for operations automation?

YES

NO

20. If Yes, does your enterprise use:

AI to enable autonomous decision making, from observing and strategizing to deciding
Robots for sewing
Robots in warehouse for picking and packing procedures
Other:

21. Does your enterprise use ML/AI for sustainable fashion?

YES

NO

Section C – Investments in ML /AI

22. How much did your enterprise invest in 2018 in AI?

23. How much is your enterprise planning to invest in the next two years in ML/AI?

24. How does your enterprise acquire or integrate AI technologies (e.g., equipment or software)?

By sharing agreements
By purchasing off-the-shelf advanced technology (e.g., equipment or software)
By leasing off-the-shelf advanced technology (e.g., equipment or software)
By licensing advanced technology

By developing new advanced technologies (either alone or in conjunction with others)
Through merger or acquisition of another enterprise with advanced technologies

By partnering with academic or research organizations

By creating start-ups

Other:

Section D – Impact of ML/AI on labour force

24. What is the current impact of adoption of ML/AI on the labour force of your enterprise, in terms of jobs loss?

Strong

Mild

Weak

25. And in the next 3 years?

Strong

Mild

Weak

26 During the years 2017 and 2018, have the employees of your enterprise received special or new training on the adoption of ML/AI?

YES

NO

27. If the answer to the previous question was positive, what was the amount of spending on training related to ML/AI, in euro?

28. Between the years 2017 and 2018, has your enterprise recruited employees pertaining to the adoption of ML/AI?

YES

NO

Ethics and AI in the fashion industry

29. On a scale from 1 to 5 (from irrelevant to very important) how would your enterprise consider the support to an "AI for Good" approach to algorithm design, customer privacy protection and loyal relationship with customers?

1 2 3 4 5

Thank you for your time!