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ARTIFICIAL INTELLIGENCE IN FASHION RETAIL: AN EMPIRICAL ANALYSIS TO INVESTIGATE CONSUMER PERCEPTION

Candidato: Simona Zucca

N° matricola: 21 G01 302

Relatrice: Prof.ssa Katia Premazzi

Did you know that the whole concept of artificial intelligence is binary?

Do you understand the irony? [...]

The language of computers is all about two values.

One and zero. One. Zero. One. Zero. To infinity.

Two values that can mean anything.

The sum of human knowledge, reduced to a two.

One and zero. The two sides of the same coin.

Two possibilities, which lead to an infinite number of possibilities.

BATMAN: Knightfall (1993-1995)

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Introduction

If in the past artificial intelligence was seen as science fiction, today it has become a reality.

Since the COVID-19 pandemic, the use of artificial intelligence and big data has expanded quickly, penetrating many aspects of our lives, starting from the sector of economy, banking, communication, health care and manufacturing to fashion, including online shopping.

Even though the Internet had previously been crucial in virtually connecting customers and sellers around the world, the global pandemic's expansion accelerated the fashion industry's digitization; in fact, during the pandemic, fashion-related commercial activities such as shopping, visiting showrooms, and attending fashion week shifted to being primarily online.

One the one hand, especially during the first months of the pandemic, the fashion retail sector was negatively affected globally: lockdown restrictions, store closures, and a change in consumer buying habits led to a drastic drop in store sales, causing a negative impact on the sales and profits of fashion companies around the world.

On the other hand, online sales have increased significantly, revolutionizing the fashion industry; brands started to embrace live streaming, virtual customer service, virtual try-on, and conversational commerce, achieving years of progress in digitization in just a few months.

Thanks to this digital transformation, many consumers could look for online solutions to meet their fashion needs. People spent more time at home and worked remotely, so online stores replaced traditional stores, becoming the point of reference for fashion enthusiasts or anyone, who wished to stay updated on the latest trends and buy their favourite without having to go out.

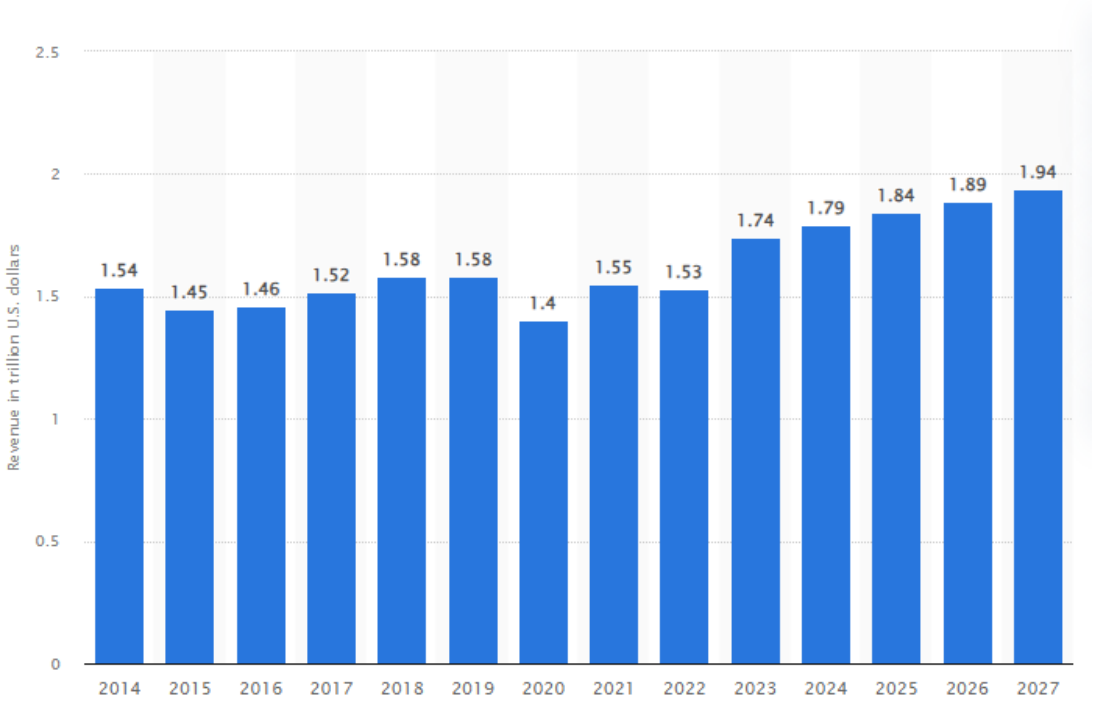
This shift to online sales disclosed many opportunities for brands and retailers who were able to adapt quickly to e-commerce: by providing a pleasant and secure online shopping experience to customers and by using new technological tools based on artificial intelligence, such as visual search, personalized product recommendations and chabots, they saw an increase in sales despite the tough times.

So, although the pandemic has been a challenge for fashion retail, the ability to reach consumers through e-commerce has enabled companies to continue to meet fashion demand, allowing the industry to remain resilient in the face of challenging circumstances.

The following graph from Statista, shows as revenues generated by the global apparel market increased gradually from 2015 until 2020, when the pandemic had a strong impact on retail. In

2022, revenues from this market were about 1. 53 trillion US dollars. The global revenue of the apparel market was forecast to continuously increase between 2023 and 2027. As shown in Figure 0, the market revenue is estimated to amount to 1.94 trillion U.S. dollars in 2027 (+11.49 %) (Statista, 2023).

Figure 0: Revenues of the apparel market worldwide from 2014 to 2027 (Statista)[1]



As mentioned above, many retailers are already embracing technological tools based on Artificial Intelligence as a driving factor for the growth of e-commerce. For instance, world famous e-commerce giants like Alibaba, E-bay and Amazon invest in R&D to develop visual recognition techniques, create algorithms to suit user content preferences, or use dynamic prices based on real-time comparisons of competing products. In the fashion field, some famous brands which adopted Artificial Intelligence in retail are Adidas, Nike, Asos, Zalando, Shein and H&M.

AI in fashion retail can be used for different purposes, for example to analyse customer data and trends, to offer virtual support through chatbots, to create personalized product recommendations and virtual try-ons which allow customers to see how the products will look on them digitally, before making a purchase.

[1] https://www.statista.com/forecasts/821415/value-of-the-global-apparel-market

However, AI and its main subfield not only can be applied in the fashion retail sector, but in every stage of the fashion value chain too, from concept and design to source of materials, production, warehouse management, shipping, as it can lead to advances including accelerating and scaling up operations, managing big volumes of data, and giving customers new ways to interact with retail and e-commerce.

This thesis first aims to explore how artificial intelligence and related digital technologies are changing the fashion industry, with a more specific and in-depth focus on the fashion retail sector. Following, with the aim of investigating how customers are perceiving these changes, afield research will be carried out through the administration of an online survey, appropriately designed to evaluate the level of exposure of the end consumer to AI-powered solutions for retail, as well as how they perceive and trust them.

This thesis is structured as follows: in the first chapter, the history of artificial intelligence, its definitions, and its basic concepts, such as Machine Learning, Deep Learning, Computer Vision, Natural Language Processing (NLP) and Robotics, will be explained in order to better understand its applications in the fashion industry, which will be discussed in the next chapters.

The second chapter shows how artificial intelligence, and its subfields, are being applied in the fashion industry, in particular along the stages of the fashion value chain, presenting the major advantages that AI can bring to this industry and the main challenges and concerns for society.

The third chapter starts with an introduction to the retail sector, tracing its historical evolution, in order to provide insights into the contemporary concept of Retail 4.0. Subsequently, the chapter delves into how the COVID-19 pandemic has hastened the expansion of e-commerce within the fashion retail sector, underscoring the pivotal significance of AI in navigating this ever-changing and demanding retail environment.

The fourth chapter aims to describe the main technologies based on artificial intelligence used in the fashion retail sector, which make the customer shopping experience more engaging; these include virtual try-on, chatbots, virtual style assistants, personalized product recommendations, visual search and smart mirrors. To provide tangible insights, each technology discussed will be accompanied by a case study featuring a fashion brand as an illustrative example.

The fifth chapter is dedicated to on-field research with the aim to investigate how consumers perceive, feel about, and trust the use of these technological AI-based tools during their online shopping experience. The chapter describes the methodology used to collect data, providing a

graphical representation of the acquired data and a conclusive critical reflection on the obtained results.

In other words, this research aims to investigate the consumer's perspective and to understand the level of exposure to the current AI-powered solutions in retail, as well as concerns and points of reluctance that could prevent retailers from using such solutions. The goal is to understand all the problematics of the current scenario to have a glimpse of how artificial intelligence, the fashion industry and its consumers can co-exist in the near future.

The will to present a thesis that delves into the impact of artificial intelligence on the fashion retail industry stems from my long-standing passion for fashion, which I have nurtured since childhood, as well as my keen interest in the ever-evolving technological advancements. As a fashion enthusiast, the choice to explore how AI is influencing the fashion retail sector and the customer shopping experience is an exciting way to blend my personal interest with contemporary technological advancements. Fashion is a continuously evolving industry, and AI is playing a significant role in the innovation and transformation of how fashion products are created, distributed, and sold.

CHAPTER 1

Artificial Intelligence (AI): history, definitions, and basic concepts

To comprehend what artificial intelligence is, it is crucial to know that it is an "umbrella term", which means there is no widely agreed-upon definition (Stone, Brooks, Brynjolfsson, et al., 2016). Rather, AI includes a set of processes, tools, and strategies, whose goal is to make machines behave intelligently, like human beings do, including abilities such as reasoning, problem solving, memory recall, learning, planning, processing natural language, perception, manipulation, social intelligence, and creativity (Luce, 2019)[2].

Artificial intelligence (also called AI) is a recent discipline which dates back to the 1950s, starting with Alan Turin's Test, progressing through early neural network theories, the distinction between strong and weak AI, and to early industrial applications of the 1980s.

Today, AI is part of people's daily lives, as well as being at the centre of the technological decisions of companies. AI has spread in several areas including logistics, industrial production, business, and process optimization. As a result, it has contributed to the development of technologies such as robotics, self-driving cars, chatbots, speech recognition and facial recognition.

In this chapter, after a brief history of AI, the different definitions of the term will be examined, followed by a more in-depth examination of the major sub-fields of AI, such as Machine Learning (which include Deep Learning), Natural Language Processing (NLP), Computer Vision and Robotics.

1.1 History of Artificial Intelligence

Artificial Intelligence lays its foundations on a path of philosophical reasoning started in the ancient Greek period. Although the ancient Greeks did not conceive artificial intelligence as it is understood nowadays, they had a rich tradition of myths, tales, legends, and philosophical thoughts that touched on artificial life, automatons, and self-operating machines that were given intellect or consciousness. Philosophers' attempts to characterise human thought as a set of mechanical operations laid the groundwork for modern AI, which was born officially in 1956

[2] Luce, L. (2019). Artificial intelligence for fashion: How AI is revolutionizing the fashion industry. Berkeley, CA: Apress.

following a seminar held on the Dartmouth College campus in the summer of that year (Corea, 2017)[3].

The development of computers, begun in the 1940s with the works of the neuroscientist Warren McCulloch and the logician Walter Pitts, has had a significant impact on the development of artificial neural networks and artificial intelligence in the following years.

In 1943 McCulloch and Pitts published a paper titled "A logical calculus of the ideas immanent in nervous activity", in the Bulletin of Mathematical Biophysics 5:115-133, in which they tried to understand how the brain could use neurons to produce overly complex patterns.

In their study, they presented a substantially simplified model of a neuron, giving an essential contribution to the development of artificial neural networks that model fundamental aspects of biological neurons. So, based on the analysis of the original biological neurons which operate in a binary system, they developed mathematical models made of neurons. However, because these neurons had limitations, other features were added to allow them to "learn." Their works were successful in demonstrating the ability of neurons to learn and adjust their actions throughout time.

During those years, the term "cybernetics" was used, to indicate “The scientific study of communication and control systems, which involves comparing human and animal brains with machines and electronic devices”[4]. The basic principle consists in studying the mechanisms of self-regulation and control present in both natural and artificial organisms with feedback capabilities, or able to respond in an adaptive way to the stresses of the environment by changing their behaviors. The research carried out by McCulloch and Pitts, based on a neural network model inspired by the functioning of the human brain, have been among the first results of the scientific community also in this field.

Because the goal of artificial intelligence is to have a machine which replicates human behaviour and reasoning, AI is understood as an extremely ambitious cybernetic concept.

Even single-task machines in a factory are an example of the use of cybernetics, as it can totally or partially replace human intervention in a production process.

[3] Corea, F. (2017). A Brief History of AI. Medium. Available at: https://francesco-ai.medium.com/a-brief-history-of-ai-baf0f362f5d6

[4] https://www.oxfordlearnersdictionaries.com/definition/english/cybernetics?q=cybernetics

In 1949, Donald Olding Hebb, a Canadian psychologist, published a book entitled "Organization of Behavior" in which he proposed a combined study of data from the physiology of the nervous system and the analysis of human behavior. In this study the links between the complex models of the human brain and artificial neurons were analyzed in detail, showing that a modification of the forces of connection between neurons could give rise to learning processes.

In other words, in his book he aimed to explain synaptic plasticity, which mean the adaptation of brain neurons during the learning process.

To explain this concept, Hebb developed the *Hebb's Rule*: "The persistence or repetition of a reverberant activity (or "trace") tends to induce lasting cellular changes that add to its stability. When an axon of cell A is close enough to excite a cell B and participates repeatedly or persistently in its firing, a certain process of growth or metabolic change occurs in one or both cells so that the efficiency of A, as one of the cells firing B, is increased".[5] The theory claims that an increase in synaptic efficacy arises from a presynaptic cell's repeated and persistent stimulation of a postsynaptic cell.

Hebbian learning is an ecologically and biologically valid learning mechanism where "units that fire together, wire together" (Hebb, 1949).

During those years, Marvin Lee Minsky[6], an American cognitive scientist, was strongly influenced by the works of McCulloch and Pitts concerning the cybernetic conceptual and mathematical models of neuronal cells and the neural networks. After some attempts, in 1951, he finally developed the first neural network machine, called "SNARC" (Stochastic Neural Analog Reinforcement Computer).

SNARC was an electrotechnical device that could learn simple concepts by connecting numerous identical artificial neurons in a network.

Despite this progress, first working neural network prototypes, namely mathematical and computer models developed to reproduce the functioning of biological neurons to solve problems, developed in the late 1950s.

[5] Hebb, D. O., *The organization of behavior; a neuropsychological theory*. New York, Wiley, 1949, P.62

[6] Marvin Lee Minsky (August 9th, 1927 – January 24th, 2016) was considered as a visionary "father of artificial intelligence" (in the manner of Turing as the term was coined by John McCarthy in 1956); he was an outspoken advocate for the belief that humans would one day build machines with intelligence equal to that of humans.

In 1950, Alan Turing, an English mathematician and cryptographer, published an article titled "Computing machinery and intelligence[7]" in the journal Mind, in which he described what became known as the “Turing Test” and in which he proposed to consider the following question: “Can machines think?”.

The Turing test was originally known as “The Imitation game”[8] and was projected to test a machine's capacity to show intelligent behaviour equivalent to that of a person; in particular, its capacity of continuing a conversation indistinguishable from that of a human being.

This game is divided into two phases: in the first session three people participate – a man, a woman, and an evaluator or interviewer. The latter is separate from the other two, because his task is to determine, through a series of questions, which interlocutor is the man and which interlocutor is the woman. The game seems quite simple, but, in reality, it is not because the two participants have different roles. The task of the man is to trick the interviewer by giving untruthful answers and trying to convince him to be the woman, while the woman, on the other hand, has the goal of facilitating the identification, by giving truthful answers. In order for the interrogator not to recognize the woman or man’s writing or voice, they must communicate by teletype. The interviewer does not know who is telling the truth and who is lying, and his purpose is to understand amongst the two players who is the man and who is the woman.

At a later stage of the game, the role of man A is replaced by a machine. If the percentage of times in which the interviewer guesses who the man is and who the woman is, is similar before and after replacing the man with the machine, then the machine itself should be considered smart. Therefore, the goal of the interrogator is to discover which is the man and which one is the woman, while the goal of the machine is to be indistinguishable from a human being.

If the evaluator could not identify the difference between the machine and the person, the machine win and it is considered intelligent because it can continue a conversation begun by a human without the evaluator notices the change.

There is also a subsequent formulation of the test, known as the “Simplified Version of Turing Test” where the interviewer must distinguish which of the two subjects is a human and

[7] Mind, Volume LIX, Issue 236, October 1st, 1950, Pp 433–460

[8] Turing’s arguments were anticipated in 1637 by René Descartes, in the fifth part of the "Discourse on the Method", in which he exposed some differential criteria between human intelligence and that of machines, by placing emphasis on linguistic behaviour.

which is the machine. In this case, the test requires the machine to act as a human being sufficiently to be mistaken as such by the interviewer.

In reality, the test was never passed. Turing was convinced that that in about fifty years, approximately in the early 2000s, some computers would pass the test. In these years, AI has progressed a lot, but his test is still very controversial and there is currently no computer program that meets the requirements to pass it.

The Turing test is a conceptual experiment whose practical value relative to the presence of intelligence in machines is almost nil. However, its importance lies rather in the type of reflections it has provoked on the concept of intelligence, mind and thought (Longo, 2009)[9]. In fact, the historic article by Turing had significant impact and provided the foundation for much following research on Artificial Intelligence. This article aroused objections and criticism, but also reflections and the ideas which gave birth of a new discipline closely related to the cognitive sciences and computer science[10]. This discipline will be called few years later "Artificial Intelligence."

In August 1955, the American computer scientist John McCarthy, along with the mathematician Minsky, and two senior scientists whose names are Nathan Rochester and Claude Shannon, released their workshop's proposal known as the "Dartmouth proposal[11]", which begins with the following statement: *"We propose that 2 months, 10-man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve*

[9] Longo, G. IL TEST DI TURING. STORIA E SIGNIFICATO (2009). Available at: https://disf.org/files/doc/longo-test-turing.pdf

[10] Despite having origins in the 19th century, computer science was officially born in 1936 with the mathematical model of calculation of the Turing machine, i.e.an abstract machine which manipulates symbols on a strip of tape according to a table of rules and that it is able of implementing any computer algorithm.

[11] The original document consisted of 17 pages and a title page. Copies of the typescript are housed in the archives at Dartmouth College and Stanford University. The first 5 papers state the proposal, while remaining pages give qualifications and interests of the four who proposed the study. In the interest of brevity, this article reproduces only the proposal itself, along with the short autobiographical statements of the proposers. http://jmc.stanford.edu/articles/dartmouth/dartmouth.pdf

themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer" (McCarthy, Minsky, Rochester, & Shannon, A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence, August 31, 1955).

McCarthy is considered as one of the fathers of AI, along with Allen Newell, Herbert A. Simon, and Marvin Minsky, as they used the word "Artificial Intelligence" for the first time to describe machines capable of reasoning and performing operations that require human intelligence.

The following year, in 1956 the field of Artificial Intelligence was officially born during the Dartmouth Summer Research Project on Artificial Intelligence: a two-months' workshop, held in the Dartmouth College in Hannover, New Hampshire (USA), organized by the four scientists mentioned above. The project was essentially an extended brainstorming session around the new field of study where about a dozen researchers participated.

Since that summer, artificial intelligence was officially a field of study, and until the 70's AI research thrived.

The conference's success encouraged substantial investments in the sector, raising funds that enabled the launch of many development programs (Haenlein & Kaplan, 2019).

There was a common sentiment of fascination and optimism towards this new powerful discipline, with a lot of hopeful and promising projections, so much so that in 1970 Marvin Minsky, in a Life Magazine[12] interview, declared that "In from three to eight years we will have a machine with the general intelligence of an average human being".

Expectations were high and optimistic, nevertheless the expected results were not achieved; the disappointment came when researchers realized things were more complex than what they have predicted. One of the main obstacles was the fact that computers at that time still could not store or fast process information as desired (Anyoha, 2017)[13]. In particular, the first signs of the

[12] Life was an American weekly magazine that ran from 1883 to 1972, then as an occasional "special" until 1978, and then as a monthly from 1978 to 2000.

[13] Anyoha, R. (2017). Can Machines Think? Available at: https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/

crisis in the field occurred in 1966 when the ALPAC[14] report criticized AI's machine translation efforts despite a 20 million dollars investment (McCorduck, 2004; Russell & Norvig, 2010)[15]. After this event, the DARPA[16], the agency responsible for financing the project, drastically reduced the investments in the field.

Across the Atlantic, the UK's Science Research Council commissioned James Lighthill, a famous British scientist, to publish an evaluation of AI advances. His assessment, published in 1973, was extremely critical of the field, concluding that "In no part of the field have discoveries made so far produced the major impact that was then promised" [Lighthill, 1973:[17] p.8]

The criticism made in the report, along with the ALPAC one, and together with the scarcity of data available to feed the algorithms and the poor computational capacity have been considered as the major causes behind the dramatic slowing down of such research. In fact, the statement of Lighthill led the British government to stop much of the British universities' studies in progress, followed by the US government which made the same choice (Haenlein & Kaplan, 2019; Russell & Norvig, 2010). This was the start of the first so-called AI Winter, lasting from mid-70's to early 1980.

In the 80's, the American systems analyst whose name is Edward Feigenbaum developed the Expert Systems and the interest in AI started to rise again. He is considered as the most important pioneer in the development of expert systems which are computer system which simulates the decision-making capacity and problem solving of a human expert about a given field (Anyoha, 2017).

Expert systems are one of the most important computer applications that have emerged in the recent decade. They enable a computer program to employ expertise to help with a wide range of problems, such as diagnosing equipment breakdowns and creating new equipment (Buchanan

[14] ALPAC (Automatic Language Processing Advisory Committee) was a committee of seven scientists led by John R. Pierce that was established by the US government in 1964 to assess advances in computational linguistics and, in particular, machine translation. Its 1966 report is famous for being critical of previous machine translation efforts and highlighting the necessity for basic research in computational linguistics.

[15] Russell, S. J., & Norvig, P. (2010). Artificial Intelligence-A Modern Approach, Third International Edition. London: Pearson Education.

[16] The Defense Advanced Research Projects Agency (DARPA) is a research and development agency of the United States Department of Defense created in 1958 by President Dwight D. Eisenhower and responsible for the development of science and technologies for use by the military.

[17] Lighthill, J., 1973. "Artificial Intelligence: A General Survey". Artificial Intelligence: A paper symposium. UK: Science Research Council. Available at: https://rodsmith.nz/wp-content/uploads/Lighthill_1973_Report.pdf

and Smith, 1988)[18]. Expert Systems became an element adopted by companies around the world, becoming a commercially successful demonstration of the power of AI techniques.

This massive real-world success of AI brought back a sense of positivity which encouraged the return of investments; studies and research on AI started again. In particular, these new development programs aroused the interest of big investors, including the Japanese Government that, with its Fifth-generation computer project, [19] aimed to give computers reasoning capabilities to eventually perform tasks like diagnose diseases, analyse lawsuits, and understand language (Pollack, 1992).

The Japanese government made resume investments and interest from some of the states, including Great Britain and the United States that already in the past were heavily involved in the study and research of Artificial Intelligence (Corea, 2017).

But, once again, expectations were too high, and, despite a 400 million dollars investment, the Japanese initiative failed to achieve many of its goals, making commercial interests decrease, and prompting Japan to offer the software to anyone who was interested, including foreigners (Pollack, 1992). This was an important fact given that Japan and the United States were competing to lead the computer technology market at the time.

After another set of unmet expectations, the fascination generated by Artificial Intelligence suffered a further decline in interest, starting from the late 1980s until early 1990s. This period is known as the second AI Winter, and the main causes were the expensive cost of maintaining the Expert Systems and, secondly, withdrawal of investment by governments because of fear of lack of returns.

Governments and investors' positive perception collapsed leading to the disruption of funding. Although investments were cut again and commercial interests in artificial intelligence were minimal, the field continued being studied and there were developments and achievements even during AI winter.

[18] Buchanan, B.G./Smith R.G., 1988, Fundamentals of Expert Systems. «Annual Review of Computer Science», vol. 3, no. 1. PP. 23-58.

[19] The Fifth Generation Computer Systems (FGCS) was a 10-year initiative launched in 1982 by Japan's Ministry of International Trade and Industry (MITI) to develop computers using massively parallel computing and logic programming (Shapiro, 1983). It aimed to create an "epoch-making computer" with supercomputer-like performance and to provide a platform for future developments in artificial intelligence, but its excessive ambitions led to commercial failure.

It is only from the 1990s that large companies began investing again, leading to big discoveries and progress in the field; from that moment on, AI began to be used successfully within a variety of technological systems.

An increase in interest and progress occurred in 1997, when IBM proved that a computer called Deep Blue computer was able to play chess and beat the world chess champion G. Kasparov. The match lasted few hours and attracted extensive media coverage across the world because it was the first game played between a man and a machine.

In 2011, IBM launched the Watson System,[20] which was subsequently tested in the American game show called "Jeopardy!", in which its objective was to answer questions posed by the host and win challenges against TV game champions. From that moment on, Watson became the reference point for cognitive systems, able to analyse human language, and of self-improvement. To date, this technology is used in many fields, including healthcare, e-commerce, fashion, chatbots, telecommunications, financial service, teaching assistant and weather forecasting.

In the new century, artificial intelligence, backed up by all evolutions in computer science, has become part of everyday life, being found in products and processes.

Academic research has made significant developments over the past two decades (Corea, 2017). In 2011 Apple launched its virtual assistant Siri on iOS, bringing AI closer to end users than anything else had before. However, it has gained widespread general recognition only since 2012, when a group of researchers developed, during conference on Neural Networks[21], an improvement of an image recognition algorithm, making it better than what the human mind can do.

As previously discussed, the history of AI is not linear regarding development and investments; in a lot of periods, there has been a lot of disbelief in the field and its possibilities. However, nowadays its uses are spread across industries and a world without the applications of AI would be difficult to imagine at this point.

[20] IBM Watson is a question-answering computer system developed by IBM, capable of answering questions posed in natural language.

[21] Neural Networks are a subset of machine learning and represent the central element of deep learning algorithms. Neural networks mimic the way biological neurons in the human brain send signals.

According to Next Move Strategy Consulting,[22] the global Artificial Intelligence will increase rapidly over the next decade. The market value was about 100 billion U.S. dollars in 2021, but it is predicted to more than double to nearly two trillion U.S. dollars by 2030, with a CAGR of 32.9% from 2022 to 2030.

The AI market covers a vast number of industries: supply chains, marketing, product making, research, analysis, and more are fields that will adopt artificial intelligence within their business. Furthermore, Al is particularly useful to improve efficiency, productivity, quality of service, and reduce human errors.

The percentage of companies in the world adopting artificial intelligence in 2022 has more than doubled since 2017, although in recent years it has stabilized between 50% and 60%. However, research firm McKinsey & Company[23] estimates that 70% of organizations will be using AI by 2030.

To date, artificial neural networks, and Deep Learning, will be explained in the last paragraph of this chapter, constitute what in the modern conception is identified under the label of AI and represent most of the applications of use with which people are in contact (Haenlein & Kaplan, 2019). However, before delving into the characteristics of artificial intelligence, it is important to analyse the term and its definitions, to have a better global understanding.

1.2 Artificial Intelligence and its definitions

To understand what artificial intelligence is, it is important to understand firstly the term “intelligence” and, secondly, to consider the subjective nature of the definition itself. In fact, each person has a personal conception of intelligence due to factors such as beliefs, experiences, and values, which may change over time, and are influenced by culture.

Intelligence (both in machines and in humans) has been widely studied by psychologists, biologists, and neuroscientists; however, it is an overly complex concept as it encompasses a

[22] NMSC., 2023, Artificial Intelligence Market Size and Share | Analysis - 2030. Available at: https://www.nextmsc.com/report/artificial-intelligence-market

[23] McKinsey & Company, founded in 1926, is a global management consulting firm which provides professional services to corporations, governments, and other organizations. It is the oldest and largest of the "Big Three" management consultancies, the world's most prestigious strategy consulting firms.

wide range of cognitive abilities, such problem-solving skills, learning capabilities and adaptability, which are difficult to fully understand.

Bearing in mind the subjective nature of the term, the Enciclopedia Treccani[24] defines the noun *Intelligence* as follows: "Complesso di facoltà psichiche e mentali che consentono all'uomo di pensare, comprendere o spiegare i fatti o le azioni, elaborare modelli astratti della realtà, intendere e farsi intendere dagli altri, giudicare, e lo rendono insieme capace di adattarsi a situazioni nuove e di modificare la situazione stessa quando questa presenta ostacoli all'adattamento; propria dell'uomo, in cui si sviluppa gradualmente a partire dall'infanzia e in cui è accompagnata dalla consapevolezza e dall'autoconsapevolezza, è riconosciuta anche, entro certi limiti, agli animali, specialmente mammiferi". This definition is human-centred, but it also gives animals a certain degree of intelligence.

According to John McCarthy (1997), the researcher who coined the expression *artificial intelligence*, "Intelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals, and some machines[25]".

This definition wants to convey the idea that intelligence can be seen as a computational process that enables an agent to achieve goals. According to McCarthy, intelligence can be understood and replicated by using algorithms and computational processes which allow an agent to solve problems, make decisions or plan actions, in an equivalent way to how an intelligent being would do.

In his vision of artificial intelligence, McCarthy recognized that intelligence is not necessarily tied to biology and can be achieved through the implementation of computational mechanisms.

From these definitions, it is clear that intelligence is a significant characteristic of human beings and animals, as a living biologic species; therefore, the term does not refer to something artificial, but to something natural and intrinsic to living beings. The reason for using the adjective "artificial" was a new necessity of science of the Fifties, to indicate the simulation of human intelligence processes by machines, especially computer systems.

[24] https://www.treccani.it/vocabolario/intelligenza/
[25]hhttp://www.incompleteideas.net/papers/Sutton-JAGI-2020.pdf

Furthermore, during the Dartmouth College di Hanover in 1956, John McCarthy – one of the founders of this discipline – decided to coin this expression also to distinguish his work from that of colleagues working in the field of cybernetics.

As mentioned at the beginning of the first paragraph, artificial intelligence is considered as an "umbrella term", because there is no universally agreed-upon and unique definition in the literature.

For instance, according to Britannica,[26] artificial intelligence is "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from experience."

According to Cambridge Dictionary,[27] artificial intelligence is "the study of how to produce machines that have some of the qualities that the human mind has, such as the ability to understand language, recognize pictures, solve problems, and learn."

Analysing these definitions, it is possible to understand that AI is a wide branch of computer science concerned with the development of smart software and hardware capable of performing tasks that typically require human intelligence, but also able to autonomously pursue a defined commitment by making decisions that were previously entrusted to human beings. Artificial intelligence-based machines can simulate, improve, and even extend upon, the intellectual capabilities of the human mind. These typical abilities concern, specifically, the understanding and processing of natural language (NLP - Natural Language Processing) and images (IP -Image Processing), learning, reasoning, planning, creativity and interacting with the external environment (Digital4, 2023)[28].

Remarkably interesting is the definition offered by the co-author of the term, John McCarthy, in his 2007 paper[29]: "Artificial intelligence (AI) is the science and engineering of making

[26] https://www.britannica.com/technology/artificial-intelligence

[27] https://dictionary.cambridge.org/dictionary/english/artificial-intelligence

[28] DIGITAL4EXECUTIVE, 2023, AI, Cos' l'Intelligenza Artificiale E Come Può Aiutare Le Imprese. Available at: https://www.digital4.biz/executive/ai-cos-e-l-intelligenza-artificiale-e-come-puo-aiutare-le-imprese/

[29]McCarthy J., 2007, WHAT IS ARTIFICIAL INTELLIGENCE?. Stanford University, CA. P.2 Available at: http://35.238.111.86/jspui/bitstream/123456789/274/1/McCarthy_John_What%20is%20artificial%20intelligence.pdf

intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable". His definition highlights that AI is a multidisciplinary field, which combines elements of computer science, mathematics, engineering, and cognitive psychology, and deals with creating computer programs or machines capable of performing tasks traditionally associated with human intelligence. Furthermore, although AI is influenced by human intelligence, it has the flexibility to explore and develop methods beyond what is naturally found in biological organisms.

A more recent definition was offered by the European Commission's[30] (Brussels, 2018) according to which "AI refers to systems that display intelligent behaviour by analysing 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 emphasises the breadth of AI applications, from software-based systems that aid with virtual tasks to hardware devices which can operate autonomously and intelligently in the physical world.

Even if there is no single definition of AI, the scientific community has found agreement in defining two different types of artificial intelligence: "artificial narrow intelligence" (ANI, also called "Weak AI) and "artificial general intelligence" (AGI, also called "strong AI").

Weak AI implements a limited part of mind and can perform narrowly defined tasks, such as solving problems, making decisions, translating texts, driving cars, recommending products and so on. Weak AI contains systems capable of simulating some human cognitive functions, without however achieving the intellectual abilities typical of humans. These are systems that can mimic and perform certain tasks or manage narrow problems intelligently but lack consciousness and comprehension in the same way that humans do. A virtual assistant that can answer user questions or a recommendation system that proposes products or content based on data trends are two such examples.

[30] The European Commission's HIGH-LEVEL EXPERT GROUP ON AI, «A Definition of AI: Main Capabilities and Disciplines», Brussels 18th December 2018. Available at: https://ec.europa.eu/futurium/en/system/files/ged/ai_hleg_definition_of_ai_18_december_1.pdf

On the other hand, strong AI systems are capable of understanding, learning, and reasoning at the same level as a human being. Furthermore, these systems can become wise and even self-conscious. In other words, strong AI systems are endowed with consciousness, understanding, awareness and their own intelligence, probably superior to that of human beings. So far, strong AI remains primarily a theory and has not been realized yet. The timing for strong AI development is still being debated among researchers and experts. Someone thinks it will take years or decades, while others think it will take a century or longer, and a minority believe it will never be achieved. As a result, strong AI raises questions about the concept of consciousness as an understanding and self-awareness and allow to consider problems affecting the ethics of the development of intelligent robots.

The American philosopher J. R. Searle raised a serious objection against the possibility of strong AI, through a famous experiment known as "The Chinese Room". The argument and thought experiment known as "The Chinese Room Argument[31]" was first described by Searle in his paper "Minds, Brains, and Programs[32]", published in Behavioral and Brain Sciences[33] in 1980. In the Chinese Room experiment, Searle imagine a native English speaker, alone in a room, with a book of instructions to use a computer program useful for responding to Chinese characters. The person in the room can receive Chinese questions only through a slot in the door; by following the program's instructions, he will be able to output Chinese symbols which are correct answers to the questions, without understanding the content of the Chinese writing.

Therefore, the person in the room can send appropriate strings of Chinese characters back out under the door by following the program for manipulating symbols and numerals just as a computer does; this leads people outside to mistakenly suppose the person understands Chinese, since he can effectively provide coherent responses to questions in the language.

Searle wants to highlight that, despite the appearance of understanding the characters or the questions, the person inside the room does not actually understand the Chinese language. Searle uses this thought experiment to challenge the claim that a computer program can have its own understanding or consciousness. In his view, consciousness and understanding require more than just the execution of algorithms as they involve a deeper level of subjective experience that

[31] Cole, D., 2004, The Chinese Room Argument. «*Plato.stanford.edu*». Available at: The Chinese Room Argument (Stanford Encyclopedia of Philosophy)

[32] Searle, J. R. «Mind, brains, and programs». The Behavioral and Brain Sciences, n. 3 (1980)

[33] Behavioral and Brain Sciences is a bimonthly peer-reviewed scientific journal of Open Peer Commentary established in 1978 by Stevan Harnad and published by Cambridge University Press

computers cannot replicate (Searle 1980). Computers merely use syntactic rules to manipulate symbol strings but could not produce real understanding. Searle's experiment shows that the assumption that human minds are computer-like computational is refuted because minds are the outcome of biological processes that computers can only simulate (Searle, 1980).

Thus, the argument has sparked extensive debate in the field of artificial intelligence, however the experiment remains a significant contribution to the discourse on the nature of intelligence, consciousness, and the limits of artificial intelligence.

1.3 Artificial intelligence and its main sub-fields

AI is wide discipline which can be divided into several subfields, each with its own focus and applications. The four primary areas of AI include: Machine Learning, Natural Language Processing (NLP), Computer Vision and Robotics.

1.3.1 Machine Learning

Machine Learning (ML) is a branch of AI and computer science which use data and algorithms to simulate the way humans learn, gradually improving its accuracy.

The American pioneer in the field of computer gaming and artificial intelligence, whose name is Arthur Samuel, is credited for coining the term, "machine learning" in his research in 1959[34].

Machine learning focuses on developing algorithms and models that allow computers to learn from, and make predictions or decisions, based on data. The primary goal of machine learning is to enable computers to improve their performance on a specific task over time, without being explicitly programmed for that task.

Unlike traditional programming where developers write explicit instructions for a computer to perform a task, in Machine Learning models, algorithms constantly learn from experience, data patterns and examples to perform new tasks and make predictions.

[34] Samuel, Arthur L. (1959). "Some Studies in Machine Learning Using the Game of Checkers". IBM Journal of Research and Development. Available at: https://ieeexplore.ieee.org/abstract/document/5389202

According to Heller (2020), a traditional system based on defined rules will perform a task in the same way every time, while a Machine Learning system can improve its performance through learning, exposing the algorithm to a greater amount of different data.

This amount of data and learning is used to "train" the program so that it can learn to do a task or an activity independently by correcting errors (Gianni, 2020; Brynjolfsson, Rock & Syverson, 2017). Training a machine learning model involves exposing it to a large amount of data and allowing it to learn from that data by adjusting its internal parameters. Through this process, the model can learn to perform a task or activity independently, making predictions, and decisions.

In other word, the process of training a machine learning model is not the same as traditional programming. Instead of explicitly programming step-by-step instructions, the Machine Learning model is capable of identify patterns and relationships within the data and then generalizing them to make predictions or judgement (Domingos, 2012)[35].

Because of the increased availability of extremely large datasets and the development in computing power, machine learning has become increasingly popular in recent years. There are several types of machine learning approaches which are designed to address several types of problems and tasks. The most important subfield of ML is known as *deep learning*. *Deep learning* employs artificial neural networks,[36] with multiple processing layers, to model and process complex data. It has achieved remarkable success in various fields, such as visual object and speech recognition, computer vision, natural language processing, drug discovery and genomics and more (LeCun, Bengio & Hinton, 2015)[37].

In Deep learning, algorithms of artificial neural networks are modelled to function as the human brain system, learning from large amounts of data (as shown in Figure 2). As a result,

[35] Domingos, P., 2012, A Few Useful Things to Know about Machine Learning. «*Communications of the ACM*», vol. 55, no. 10, 1 Oct. 2012, p. 78. Available at: https://sites.astro.caltech.edu/~george/ay122/cacm12.pdf

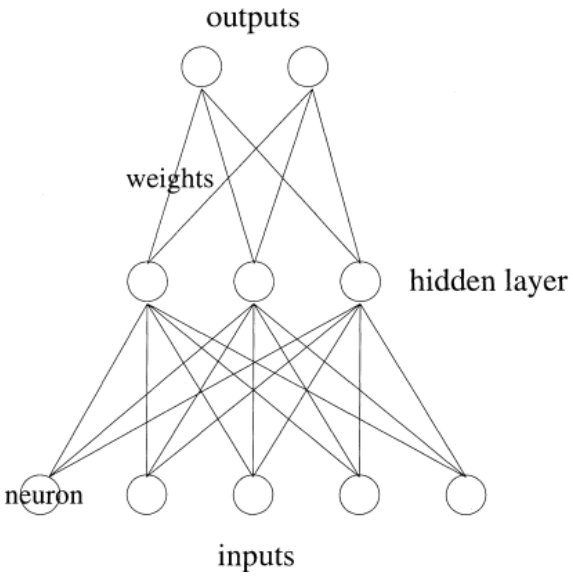
[36] Artificial neural networks are a sub-category of machine learning models and consist of computational model composed of artificial "neurons", inspired by the simplification of a biological neural network. Neural networks provide a higher level of complexity because, instead of taking input data and generating an output in a linear way, it is composed by intermediate nodes, in the so-called "hidden layers" with its own synapses which are interconnected with other nodes, that then transform data of the input layers in output layer results (Luce, 2019).

[37] LeCun, Y./ Bengio, Y./ Hinton, G., 2015, Deep learning. «*Nature*» 521, 436–444. Available at: https://www.nature.com/articles/nature14539#citeas

deep learning models capture information from multiple data sources and analyse that data in real time, without the need for human intervention. It is a learning process in which the machine evaluates and analyses the input data in a variety of ways until it finds a single acceptable output. It is also known as machine self-learning. The machine employs several random programs and algorithms to map the raw sequence of input data to output (Rancho Labs, 2021)[38].

Deep learning requires a very powerful computational capacity to support different layers of calculation and analysis (Gianni, 2020).

Figure 1.1 Architecture of a neural network[39]



1.3.2 Natural Language Processing (NLP)

NLP is a branch of artificial intelligence and computational linguistics that focuses on enabling computers to understand, interpret, and generate human language in a way that is both meaningful and useful. In other words, NLP is method of computational analysis of human languages that allows computers to "achieve human-like language processing for a range of tasks

[38] Rancho Labs, 2021, "6 Major Sub-Fields of Artificial Intelligence." «*Medium*». Available at: https://rancholabs.medium.com/6-major-sub-fields-of-artificial-intelligence-77f6a5b28109#:~:text=Deep%20Learning,identifies%20a%20single%20acceptable%20output

[39] Architecture of a neural network. Interdisciplinary Computing in Java Programming Language. The Springer International Series in Engineering and Computer Science (SECS, volume 743). Sun-Chong Wang, 2003. P.82.

or applications" (Liddy, 2001)[40]. NLP allows a machine to mimic human natural language to comprehend and interpret data (Lancho Labs, 2021).

As the name suggests, NLP is a new approach to understanding the process of human communication and it is primarily concerned with processing natural language datasets, such as text corpora or speech corpora, using neural network-based machine learning approaches.

Some NLP applications include virtual assistants, automatic translation, speech recognition, question answering and devices or software such as Amazon, Alexa, Siri and Google Home. Through these devices, humans and computers can interact using an oral natural language. Concerning textual communication, NLP enabled the creation of chatbots, software applications which simulates human conversation through text for different tasks (such as online customer assistance).

NLP continues to evolve with advances in machine learning and deep learning, and it plays a vital role in making human-computer interaction more intuitive and efficient.

1.3.3. Computer Vision

"If we want machines to think, we need to teach them to see" (Li, 2015)[41].

Computer vision is a field of artificial intelligence and computer science that focuses on enabling computers to identify, analyse and interpret visual information from the real world. It involves the development of algorithms, techniques, and models that allow machines to process, analyse, and make sense of images or videos, just like a human would. In fact, the goal of computer vision is to replicate human visual perception and understanding.

It extracts visual information from any data, including photos and video files within PDF documents, Word documents, PowerPoint presentations, graphs, and photographs, using deep learning and pattern recognition (Rancho Labs, 2001).

Some common applications of Computer Vision include facial recognition, autonomous vehicles, healthcare to assess a patient's health status by using MRI scans, X-rays, but also retail to analyse of customer behaviour in stores and optimize the shopping experience and product

[40] E.D., Liddy. Natural Language Processing. Syracuse University, 2001. Available at: https://surface.syr.edu/cgi/viewcontent.cgi?article=1043&context=istpub

[41] https://www.wired.com/brandlab/2015/04/fei-fei-li-want-machines-think-need-teach-see/

placement. Concerning the fashion retail industry, computer vision has found numerous applications enhancing various aspects of the shopping experience and supply chain management. Some examples are (Munawar, 2023; Intelistyle):

- Virtual try-on – virtual fitting room applications allow potential customers to try on a garment or accessory using various software applications, such as augmented reality (AR) or virtual reality (VR). It is possible to try on dress, glasses, or watches in real-time easily changing its colour and shape.
- Style Recommendations – computer vision algorithms can suggest personalized clothing and accessory recommendations, by analysing a customer's preferences, past purchases, and browsing history.
- Size Recommendation – computer vision can analyse a customer's body measurements and suggest the best-fitting sizes for clothing items, reducing the need for returns due to sizing issues.
- Visual Search – this application of CV allows customers to take a photo of an item they like or show an image to a search engine; computer vision algorithms, by analysing the image, can find similar products for the customer to consider.
- Visual Merchandising – computer vision can assess how shoppers interact with displays and products in-store, helping retailers optimize visual merchandising strategies.
- Inventory management – computer vision can automate inventory tracking and management by identifying and categorizing products in real time, helping retailers to quicky restore items and streamline the restocking processes.

Other AI applications in the field of fashion industry will be detailed in Chapter two, while AI applications in fashion retail in particular will be detailed in Chapter four.

1.3.4 Robotics

Robotics is a field of artificial intelligence, mechanical engineering and computer science which aim to create machines which can perform programmed tasks without further human intervention (Martin, 2021)[42].

Robots[43] are autonomous or semi-autonomous machines that can perform tasks, interact with, and manipulate the environment like humans do (Russell & Norvig, 2009), often using sensors (such as cameras, microphones, gyroscopes, and accelerometers) and AI algorithms to measure their own motion and achieve their goals.

Robotics involves integrating various AI techniques to enable robots to perceive, reason, plan, and act in dynamic and unpredictable environments.

Robots have always been a prominent feature in popular imagination and culture for a significant amount of time. Science fiction literature and movies have often depicted futuristic worlds where robots are integral parts of society, performing diverse tasks and even showing human-like qualities.

However, the reality of robotics and its current applications is less dramatic and more grounded. Robots today are designed for specific purposes, such as manufacturing (robots can perform automated tasks, helping or replacing field workers), exploration (including space, deep sea, and other challenging terrains) and healthcare (robots can execute surgeries or help rehabilitation of patients). Robots are becoming increasingly useful also in the fashion industry, in fact their precision, speed, and automation capabilities are being used to enhance efficiency, creativity, and sustainability within the fashion sector. Robots can help in the supply chain, with warehousing tasks of picking and packing, for example (Luce, 2019), or in the manufacturing processes, including cutting, sewing, and assembling.

After having analysed the major sub-fields of AI, its applications in the field of fashion industry will be described and analysed deeper in the following chapter.

[42] Martin, A., 2021, Robotics and Artificial Intelligence: The Role of AI in Robots. «*AI Business*». Available at: https://aibusiness.com/verticals/robotics-and-artificial-intelligence-the-role-of-ai-in-robots

[43] The term Robot, coined by the Czech writer and journalist Karel Čapek, derived from the Czech term *robota*, synonymous with slavish or forced labour; the robot is therefore, or should be at the service of man (Treccani 90).

CHAPTER 2

AI approaches and technologies applied in the fashion industry

Artificial intelligence and its subfields are powerful tools which can be used across the fashion industry, from concept and design to the source of materials, production, inventory management, logistics and distribution, retail and sales, marketing, returns and after-sales service.

Nowadays artificial intelligence is extensively employed in the stages of the fashion value chain to enhance efficiency, accuracy, decision making processes, while also improving the shopping experience for customers.

This chapter starts with an introduction of the fashion value chain and its main stages; following the major AI applications in the fashion industry will be described and the most significant challenges related to the introduction of this recent technology in this industry will be addressed.

2.1 Introduction to the fashion value chain

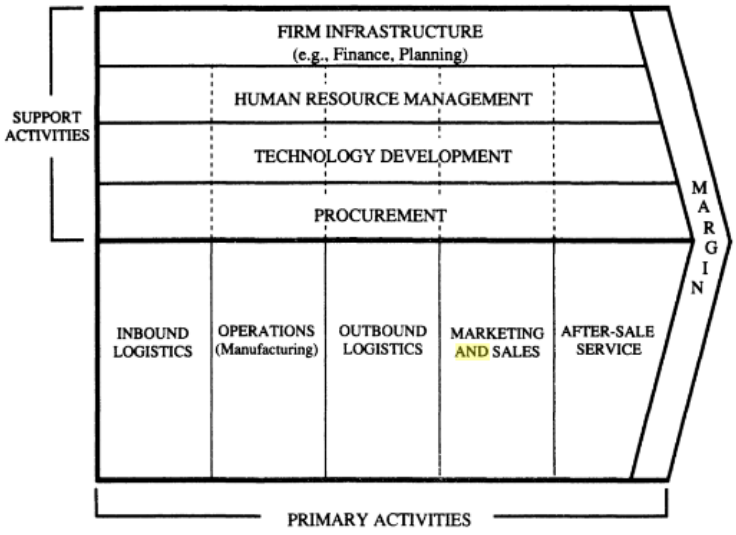
The term "value chain" was first introduced and described by Porter in 1985 in his book "Competitive Advantage of Nations: Creating and Sustaining Superior Performance".

A value chain is a concept to describe the sequence of activities and processes undertaken by a company or an industry to create and deliver a product or a service to customers (The oboloo Team, 2023)[44]. It encompasses the entire journey of transforming raw materials into the final product that reaches the end customer. In particular, the value chain identifies every stage in the process in which value is added to a product, starting with the sourcing of raw materials, designing, manufacturing, distribution, marketing, and, finally, ends with customer support (The oboloo Team, 2023).

As illustrated in Figure 3, the value chain consists of primary activities and supporting (or secondary) activities that collaborate to add value to a product or service during each stage.

[44] https://oboloo.com/glossary/value-chain/

Figure 2. Porter's Value Chain[45]



According to the IfM[46] "The idea of the value chain is based on seeing a manufacturing (or service) organization as a system, made up of subsystems each with inputs, transformation processes and outputs. Inputs, transformation processes, and outputs involve the acquisition and consumption of resources – money, labour, materials, equipment, buildings, land, administration, and management. How value chain activities are carried out determines costs and affects profits".

The value chain concept emphasizes that each step in the process should contribute to increase the overall value of the final product. By optimizing these activities and ensuring they are aligned with the company's strategy and customer's needs, businesses can achieve competitive advantages, cost efficiencies, and differentiation from their competitors (Tardi, 2023)[47].

Concerning the fashion industry, in particular the fashion apparel, the value chain refers to the complex network of interconnected activities and processes involved in creating, producing, and delivering fashion products to consumers while adding value at each stage. In other words, it represents the full journey that fashion goods take from conception and design to final purchase and use by consumers. Stakeholders include growers of silk, cotton, wool and linen, textile

[45] Porter M., *Competitive Advantage of Nations: Creating and Sustaining Superior Performance.* Free Press, NY (2004). P.41

[46] Institute for Manufacturing (IfM), "Decision Support Tools: Porter's Value Chain", Cambridge University, available at: https://www.ifm.eng.cam.ac.uk/research/dstools/value-chain-/

[47] Tardi, C. What Is A Value Chain? Investopedia (2023). Available at: Value Chain: Definition, Model, Analysis, and Example (investopedia.com)

manufacturers, distributors, retailers, third-party logistics providers and consumers (Oracle, 2023)[48].

Transparent communication between all the parties in each stage is essential for shortening lead times, improving quality, and ensuring prompt delivery to retailers and customers. Furthermore, an effective fashion value chain leads to decreased production, inventory, and logistics expenses, while simultaneously improving customer contentment (Oracle, 2023).

The fashion value chain begins with the creation of design for garments or accessories, including specifications such as fabrics, colours, buttons, zips to be manufactured. After these requirements, the manufacturer gets the raw materials, manufactures, assembles the goods, and distributes the finished products to warehouses. Following that phase, the final products are conveyed to wholesalers and retailers, which include both physical storefronts and online platforms, for consumer purchase. Retailers not only sell products, but also often provide customer support services to answer questions and manage returns (Oracle, 2023).

The fashion value chain is essential for brands and retailers as it guarantees that they can produce and deliver the clothing and accessories at the right time, to meet ever-changing customer needs, in a highly competitive market.

The configuration of a fashion value chain can differ based on business models, types of fashion products, and target market segments. However, a standard fashion value chain typically follows this structure:

- **Concept and design:** this step involves the creative process of designing new fashion products based on market trends, consumer needs, and brand identity. Designers create sketches, patterns, and prototypes to bring their concepts to life.
- **Raw materials acquisition:** this process is about finding and obtaining the necessary raw materials and components to create clothing, accessories, and footwear. This stage may include sourcing directly from cotton, silk, or flax, as well as from third-party providers, who are often local. The main goal of this step is to buy high quality resources at the lowest possible cost, while considering fair labour practices and environmental concerns.

[48] Sampson L. Fashion Supply Chain: Everything You Need to Know: Oracle.com. Published May 9, 2023. https://www.oracle.com/ retail fashion fashion-supply-chain

Material sourcing plays a critical role in the value chain, as it greatly affects the quality, availability and cost of materials which ultimately impact the final product's quality, production timeline and overall costs.

- **Manufacturing:** during this process, which takes place in factories, raw materials are transformed into finished products which are prepared for shipment and distribution, to wholesalers and retailers. Manufacturers can add value by improving their production processes or using more advanced technology (The oboloo Team, 2023).
- **Logistics and distribution:** logistics include warehousing and inventory, domestic and export distribution. The finished goods need to be transported to various distribution centres, wholesalers, retail stores, or online platforms. Distributors can add value by optimizing logistics and ensuring on-time delivery technology (The oboloo Team, 2023).
- **Retail**: Retailers, including both physical stores and e-commerce, sell fashion products directly to the end consumers. They manage inventory, display products, and interact with customers to answer their questions about deliveries, products, and provide information to ensure they are satisfied with their purchases, and eventually assist them with returns and exchanges. Providing good after-sales service is important for customer satisfaction.
- **After-sales service**: this phase, which is related to the retail one, refers to the ongoing assistance and support that a company offers to clients after they have bought a product or service (Tyagi, 2023). This phase involves providing customer support, handling customer complaints and returns, and addressing inquiries to ensure customer satisfaction.
- **Marketing and promotion**: this phase includes creating brand awareness, marketing campaigns, and promotional activities to attract customers and drive sales.

2.2 Fashion value chain and its current AI applications

A well-managed fashion value chain leads in faster turnarounds, cheaper costs, and a better customer experience, allowing fashion manufacturers and retailers to optimize revenues.

To achieve those goals, businesses rely significantly on AI-based technology to control every step of their value chains.

Artificial intelligence is present in all these areas (concept and design, raw materials acquisition, manufacturing and assembly, logistics and distribution, retail, after-sale service, marketing, and promotion), even if in some, its presence is more spread.

2.2.1 Concept and design

During the concept and design phase, AI can be used to analyse historical sales data and consumer preferences for elements such as colour, fabric, patterns and cut, or to suggest design ideas and forecast future trends and buying behaviours, which allow companies to plan the amount of goods to be manufactured and avoid overproduction. Furthermore, AI can be used in generative design too, which helps designers and companies in the creative process. Tools such virtual prototyping based on AI can help designers to see and refine their creations before production.

In other words, AI is currently mainly being applied in concept and design through trend forecasting research and generative design methods. Let's analyse these two tools to better understand the AI applications.

Trend forecasting research

Trend is a common word in the fashion industry and refers to the general direction in which a situation is changing or developing (Marinoni, 2019). It can be, for instance, the bag or the glasses of the moment, the boots of the season or the colour of the year. Trend research is about identifying and understanding these patterns, as well as predicting the future trend scenarios.

Since 1960's trend books were used to inspire designers and manufacturers with colours and ideas. However, starting from the late 90's, with the growth of digitalism, trend forecasting online platforms started to emerge causing a big shift from trend books to online platforms with a fast and international point of view (Marinoni, 2019).

In the late 2000's there was another significant transition in the trend research industry: data-driven platforms appeared all aided by the exponential expansion of technology and artificial intelligence. Nowadays the world is fast-paced, and with social media dictating trends, they can appear and disappear at the same rate (Worth, 2015).

Collecting data from social medias, such as Instagram, Pinterest, Facebook, and others, can provide insights about emerging trends and where they are located on the trend diffusion curve, showing whether they are popular only among trendsetters and innovators, or have already

reached majority, or are in decline. Artificial intelligence enables the examination of large volumes of data collected through social media and other online channels.

People spontaneously post millions of pictures, videos, stories, and texts every day, and these data can be later scanned through computer vision to analyse visual content and through natural language process for textual content. Indeed, computers can recognize the different clothing items, a skill acquired through their exposure to a pre-existing dataset of images which have been labelled with specific clothing attributes. This is possible using deep learning which allows to train computers to apply these attribute classifiers to all future photos without human supervision (Matzen, Bala & Snavely, 2017)[49].

Moreover, deep learning combined with computer vision (CV) and natural language processing (NLP) enables the clustering of images with similar attributes, understanding characteristics such as relevance and geographical occurrence.

This AI method can be used on social media posts, e-commerce images, street style picture or also in runway photos from fashion weeks, allowing trend forecasters to monitor clusters and their evolution over time, and make assumptions about the future of the trend from which the cluster is a part of.

Generative design methods

Concerning the second tool, generative models are a branch of AI connected to unsupervised learning[50], a type of machine learning which enables the collection of a huge dataset and the training of a model to produce new similar data , without human intervention (Karpathy, 2016).

Generative models are a very promising technology in this sector as they allow to create generative designs; computers can produce non-existent images based on existent ones, making them some sort of AI fashion designers. Generative models enable to create new clothing and change their colours, textures, and shapes.

[49] Matzen K./ Bala K./ Snavely N., 2017, Exploring world-wide clothing styles from millions of photos. StreetStyle. Available at: StreetStyle: Exploring world-wide clothing styles from millions of photos (arxiv.org)

[50] Unsupervised learning is based on machine learning algorithms to analyse and cluster unlabelled datasets. These algorithms discover hidden patterns or data groupings without the need for human intervention. Its ability to discover similarities and differences in information make it the ideal solution for exploratory data analysis, cross-selling strategies, customer segmentation, and image recognition (IBM).

2.2.2 Raw materials acquisition

During material sourcing, AI is useful for aiding farming of natural fibres and in the textiles field it can help the production knitted and woven textiles.

During material sourcing, if a garment is made with natural vegetable fibres, fashion meets another important industry where AI can be applied: agriculture. AI can help farmers in analysing daily data, providing real-time information such as weather conditions, temperature, water usage or soil conditions (Walch, 2019)[51]. Furthermore, sensors can detect illnesses, pests, and reduced plant nutrition, as well as apply the proper pesticides where needed, minimizing overuse (Walch, 2019).

Moreover, the society is shifting from a rural to a more urban society, causing a labour shortage in farms. AI can help by developing agricultural robots that can fill this void and do activities quickly and efficiently, such as harvesting huge crops and elimination of weeds with accuracy (Walch, 2019).

Concerning textile production, AI applications are fairly new, and are not widely spread yet (CIOReview, 2019)[52]. The uses are concentrated mostly in fabric quality control, patterns inspections, colour matching and defects detection, making processes more efficient and decreasing errors.

During the knitting and weaving processes, computer vision and machine learning may detect faults in the fabric's pattern, a procedure that would take longer and be vulnerable to human error if done manually. This significantly reduces the time needed to evaluate items prior to manufacture.

Moreover, through an automated knitting machine based on deep learning software, it is possible to generate different knitting patterns based on a photograph of a knitted garment. While it is not widely used now, those efforts are intriguing in terms of imagining a future with AI-driven textile production.

[51] Walch, K. (2019). How AI Is Transforming Agriculture. Forbes. Available at: How AI Is Transforming Agriculture (forbes.com)

[52] CIOReview (2019). How Important AI is in the Textile Industry? Available at: How Important AI is in Textile Industry? (cioreview.com)

2.2.3 Manufacturing and assembly

During the apparel production step, the innovative solution brought by the development of artificial intelligence are the sewing and textile handling robots.

Until recently, machines struggled to match humans' agility and talents when managing delicate materials like fabric. Nevertheless, with the advancement of technology such as machine learning, computers are being educated to perform such activities more effectively (Wall Street Journal, 2018)[53].

AI-powered robots are used to speed up processes and bring garments production back to western countries, but also to enhance precision and speed in garment manufacturing which leads to higher production efficiency. Furthermore, AI-powered visual inspections can improve quality control and packaging of the product, by detecting defects and inconsistencies.

An important problem when talking about clothing manufacturing is that most Western countries, including some of the biggest apparel consumers, such as the United States, Germany, UK, Italy, France, and Brazil (Common Objective, 2018)[54], have a large portion of their garments produced externally, often in the Asia-Pacific region, which then are shipped back to their respective countries. This practice is used because the cost of making this back-and-forth shipment is still lower than the cost of producing clothes internally. This phenomenon has strong environmental impact, thus introducing robotic manufacturing in Western countries could be helpful: by lowering labour costs, local production increases, and environmental problems may be decreased.

On the other hand, the development in automation in garment production raises discussions about replacing humans with machines. This situation could lead to the potential employment loss of numerous employees, who are often the family's primary source of income.

The ethics of introducing robots to the textile manufacturing business will be discussed further in the last paragraph of this chapter.

[53] Wall Street Journal. (2018). The Robot Revolution: Automation Comes into Fashion - Moving Upstream. Available at: https://www.youtube.com/watch?v=OsSDI8wWAyQ&ab_channel=WallStreetJournal

[54] Common Objective. (2018). Volume and Consumption: How Much Does The World Buy? Available at: https://www.commonobjective.co/article/volume-and-consumption-how-much-does-the-world-buy

2.2.4 Logistics and distribution

The process of logistics and distribution include a series of activities, such as inventory management, warehousing, domestic and international distribution to different companies which can be physical retailers, e-commerce retailers or both.

Artificial intelligence can be used to either speed up warehouse procedures with robotics or to better arrange stocks with demand forecasting. Only 6% of warehouses now use AI solutions in their processes (Robotics and Automation News, 2019)[55], which is a small number when compared to the benefits that these technologies can offer to the sector.

According to a Gartner's survey (2023), demand forecasting is the most extensively used machine learning application in supply chain planning. According to the study, 45% of organizations in the USA are already employing the technology, and 43% aim to use AI-powered demand forecasting during the next two years.

Let us undertake an examination of warehouse robotics and demand forecasting.

Warehouse robotics

Warehousing is traditionally considered a low-tech sector; however, the biggest innovation are the warehousing robots that can complete tasks of picking and moving products autonomously, replacing humans in an industry with a shortage of specialized labour (Robotics and Automation News, 2019). In fact, according to the Chartered Institute of Logistics and Transport,[56] 42% of logistics firms claim that there is a difficulty in finding enough workers with specific skills for this job (CILT, 2019). Robots with material handling skills can fill this gap.

In addition to robots, machine learning, natural language processing and computer vision are also used. Machine learning uses algorithms which make practical decisions for the warehouse. Using data gathered from sensors, it detects patterns and suggests actions such as speedier

[55] Robotics and Automation News. (2019). White Paper: AI and the Business of Fashion. Published in association with Geek+. Available at: AI-and-the-Business-of-Fashion.pdf (geekplus.jp)

[56] Chartered Institute of Logistics and Transport (CILT) is a leading professional body representing the transport and logistics industries worldwide.

replenishment of virtually out-of-stock products, shorter walking routes, and improved inventory arrangement (Sunol, 2022)[57].

NLP technology enables the implementation of voice-activated picking procedures, granting workers the ability to perform tasks without using their hands, thereby enhancing safety. Intelligent eyewear, for instance, is equipped with cameras that use advanced visual processing to autonomously identify barcodes. Furthermore, employing computer vision, cameras strategically positioned throughout the warehouse ease comprehensive monitoring of product movement from start to finish (Sunol, 2022).

Demand forecasting

Concerning the other tool, demand forecasting, the current scenario of the fashion industry presents a rapid, trend-cantered, and seasons-dependent landscape. In addition, the ever-shifting social and cultural trends, fuelled notably by the influence of social media, contribute to an even swifter pace of change. The detrimental impact of this fast-paced and competitive sector on the environment are beginning to be very well known and discussed: within this context, artificial intelligence, with its demand forecasting capabilities, offers a valuable opportunity for brands to manufacture only what is likely to be bought, thus avoiding wastage.

Predictive analysis, involving a series of techniques which encompasses data mining, statistics, modelling, and machine learning (Pat Research, 2020)[58], aims to predict the consumer demand for products or services, allowing companies to prudently plan the quantity of goods to be fabricated.

Demand forecasting can be achieved through a qualitative or a quantitative approach. The qualitative approach takes into consideration consumer surveys and expert viewpoint, whether supported by historical data or not, and translating qualitative insights into quantitative approximations (Chambers, et al., 1971)[59].

[57] Sunol, H., 2022, Warehouse Technology: Artificial Intelligence (AI). Articles.cyzerg.com. Available at: https://articles.cyzerg.com/warehouse-technology-artificial-intelligence-ai#:~:text=In%20the%20MHI%20Annual%20Industry,are%20currently%20using%20AI%20technology

[58] PAT RESEARCH, 2020, What is Predictive Analytics? Available at: What is Predictive Analytics ? (predictiveanalyticstoday.com)

[59] Chambers J./ Satinder K./ Smith D., (1971). How to Choose the Right Forecasting Technique. Available at: https://hbr.org/1971/07/how-to-choose-the-right-forecasting-technique

The quantitative approach, on the other hand, relies significantly on data, such as time-series analysis related to consumer demand, a method that foretells future occurrences by analysing data amassed over time (Luce, 2019), or such as novel methodologies incorporating sophisticated machine learning techniques and algorithms.

By using algorithms, it becomes possible to identify demand catalysts within extensive datasets, thereby giving more precise prognostications of demand (Kharfan & Chan, 2018)[60]. Several factors can be incorporated into the prediction process, such as web analytics or social media inputs. This is eased by the automation inherent in machine learning, empowering computers to autonomously discern significant signals from useless ones (Chave, 2018)[61].

Given the rapid mutability of consumer preferences (Nenni et al., 2013)[62], demand forecasting can give a better insight on which direction to go in such a swiftly evolving backdrop.

2.2.5 Retail

Retail has a lot of examples of AI applications, both in e-commerce, with virtual try-on, chatbots, virtual style assistants, personalized product recommendations and visual search, as well as in brick-and-mortar stores, with smart mirrors which rely on a combination of AI and augmented reality. These applications will be described and detailed in chapter four.

2.2.6 After-sales service

During the phase of returns and after-sales service, AI algorithms can provide valuable support to help retailers in inventory management, in cost reduction by automating and optimizing the process of handling returns, and in customer service through chatbots.

Concerning the inventory management, Machine Learning algorithms, through the analysis of historical data of clothes and accessories returned for refunds can help retailers in making

[60] Kharfan M./Chan V., 2018. Forecasting Seasonal Footwear Demand Using Machine Learning. Available at: https://dspace.mit.edu/bitstream/handle/1721.1/117612/Chan_Kharfan_2018_ Capstone.pdf?sequence=1

[61] Chave C., (A.A. 2017-2018), Supply Chain Management: Cognitive Demand & Readiness Assessment. Tesi di Laurea. Available at: https://webthesis.biblio.polito.it/9444/1/tesi.pdf

[62] Nenni M.E. et al., 2013, Demand Forecasting in the Fashion Industry: A Review. «*International Journal of Engineering Business Management*», vol. 5, no. 1. Available at: Demand Forecasting in the Fashion Industry: A Review - Maria Elena Nenni, Luca Giustiniano, Luca Pirolo, 2013 (sagepub.com)

informed decisions about how to reintegrate products into their inventory by accurately assessing the quality of returned items and their potential for resale. This optimization cuts overstocking of commonly returned items and guarantees that desirable items are quickly available for resale.

AI also enables the automated returns processing which streamlines and speeds up the evaluation, refund, or exchange process, making it more efficient for both customers and retailers.

In particular, deep learning algorithms, together with computer vision, are able to analyse the reasons for returns, checking product conditions, and deciding whether a return is eligible for refund or exchange. This reduces manual intervention of retailers and speeds up the return process.

AI has shown its significant value in customer care as well, primarily through the implementation of chatbots, which function as digital customer portals. These AI-powered chatbots act as complementary aides, rather than as substitutes, for human customer service and their benefits in this context are multifaceted.

Firstly, their remarkable speed and efficiency streamlines processes, ensuring swift query resolution. In fact, chatbots are useful in handling routine inquiries, managing the waiting time until a "real" service representative is available, and in retrieving of essential information, such as order number or email which can be useful for the service representative to handle a customer's request. In this sense, chatbots alleviate the burden on human customer service teams by tackling mundane, yet time-consuming tasks, allowing the human agents to focus on more complex issues (Quanos Solutions, 2023)[63].

Secondly, they offer continuous support 24/7, unaffected by traditional service hours, holidays, or weekends. This is because chatbots are artificial intelligence-powered automated systems that can interact with users and give support without requiring human presence in real-time.

In essence, the integration of AI-powered chatbots revolutionizes customer support during returns and after-sales service. By offering round-the-clock availability, rapid response rates, and

[63] GmbH QS. Detail. quanos.com (2023). Available at: AI Technology in After Sales - 4 Use Cases (quanos.com)

efficient task management, these chatbots enhance customer experiences, while optimizing the productivity of human support teams (Quanos Solutions, 2023).

2.2.7 Marketing and promotion

During the phase of marketing and promotion AI can analyses customer data to create targeted marketing campaigns and personalized recommendations by using advanced algorithms and machine learning techniques.

AI-driven marketing starts with collecting diverse customer data from various sources, including demographic information, purchase history, browsing behaviour and social media interactions. The larger and more detailed the dataset, the more effective AI can be in creating personalized campaigns.

Raw data collected are then cleaned by AI algorithms which organize and structure them to eliminate inconsistencies and irrelevant information. After that process, AI uses clustering algorithms to group customers into segments based on similar factors (such as demographics, behaviour, interests, and purchase patterns).

After that, AI algorithms analyse customer behaviour patterns within each segment; this includes understanding which products they view, how often they visit the website, their click-through rates, and more. This, together with the analysis of historical data related to customer behaviour and purchases, helps in understanding customer preferences, and predict what products customers might be interested in and when they are likely to make a purchase.

Many brands are already using the power of AI to personalise marketing emails, based on consumer preferences and behaviours to increase engagement and persuade them to convert or make a buy. In fact, the AI automates the segmentation process and provides tailored content via email, SMS messages, and in-app notifications based on each recipient's lifecycle stage (Mikalef et al., 2021)[64].

Artificial intelligence allows brands to obtain deeper consumer insights, hence offering them the best possible experience. Moreover, by extensively reviewing consumer data and

[64] Mikalef P., Conboy K., Krogstie J., Artificial intelligence as an enabler of B2B marketing: a dynamic capabilities micro-foundations approach. *Industrial Marketing Management*, 98 (2021).

understanding what their customers really want, brands can boost their ROI, avoiding overspending on inefficient digital advertising (Peyravi et al., 2020)[65].

In essence, AI can be very advantageous for marketers, as it allows to create targeted marketing campaigns and personalized recommendations that resonate with individual customers, enhancing their experience and increasing the likelihood of conversion (Theodoridis et al., 2019)[66].

2.3 Considerations and ethical concerns about the implementation of AI in the fashion industry

Artificial intelligence is rapidly evolving and, as discussed in the previous paragraphs, already has several applications in the fashion industry which enhance efficiency, increase productivity, reduce costs, and streamline processes. Furthermore, AI contribute to more personalized and convenient shopping experiences for consumers, ultimately shaping the future of the fashion retail (Fashion Retail Academy, 2023).

AI's capacity of performing complex and heavy tasks, with significant efficiency and precision, and of analysing massive amounts of data and learn from patterns opens new opportunities for designers, manufacturers, retailers, and customers (Fashion Retail Academy, 2023).

In other words, AI is revolutionizing the way fashion is produced, promoted, and consumed.

However, despite these several advantages, there are also hurdles to contemplate when dealing with AI's integration into the fashion industry.

One of the major ethical concerns pertains to the likelihood of AI displacing human labour. With AI algorithms capable of performing the tasks carried out by designers, producers, marketers, and other fashion professionals, there is a potential for job displacement, also known as technological unemployment. This phenomenon occurs when new inventions, advancements in technology or the use of artificial intelligence alter the nature of work, in this case the

[65] Peyravi B., Nekrošienė J. , Lobanova L. . Revolutionised technologies for marketing: theoretical review with focus on artificial intelligence *Bus. Theor. Pract.*, 21 (2) (2020).

[66] Theodoridis P.K., Gkikas D.C. How artificial intelligence affects digital marketing. *Strategic Innovative Marketing and Tourism*, Springer, Cham (2019).

production process, displacing several jobs or even eliminating tasks that were previously carried out by human workers (Pettinger, 2017).

This phenomenon can have repercussions, not only in the fashion industry, but on the global economy too; for this reason, companies must understand the importance of adopting ethical and responsible approaches towards AI (Ginsberg, 2023)[67].

As previously said, incorporating robots into the manufacturing industry brings environmental advantages as it allows companies to reshore[68] their manufacturing processes; this consequently reduces production activities in the Asia-Pacific regions, as well as the necessity for transportation of goods from those countries.

Countries such as China, Bangladesh, Vietnam, and Cambodia produce large amount of clothing and accessories due to lower labour costs and due to a more skilled workforce in the garment and textile industries compared to western nations. The combination of a more skilled workforce and cost advantages makes outsourcing manufacturing to these countries financially attractive for Western companies.

However, the integration of AI-powered robots in the manufacturing could have substantial economic repercussions for the economies of these Eastern nations, and not only; as previously stated, automation will put many jobs at risk. For young people especially, it will disproportionately affect less qualified workers which work in sectors like manufacturing and retail.

In fact, according to a PWC analysis conducted in 2018[69], the manufacturing sector may have the largest impact in terms of absolute numbers of jobs that might be automated (with an estimated automatability of 45%). The wholesale and retail trade sector, on the other hand, has a moderately high automatability estimate of 34%. This means that the manufacturing will be the most impacted industry in terms of labour.

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[67] YEC- Ginsberg B., 2023, Council Post: Artificial Intelligence in Fashion. «*Forbes*». Available at: https://www.forbes.com/sites/theyec/2023/02/21/artificial-intelligence-in-fashion/

[68] According to Cambridge Dictionary the term *reshore* refers "to move a business or part of a business that was based in a different country back to its original country".

[69] PwC. (2018). Will robots really steal our jobs? An international analysis of the potential long-term impact of automation. PricewaterhouseCoopers LLP. P.18
Available at: https://www.pwc.com/hu/hu/kiadvanyok/assets/pdf/impact_of_automation_on_jobs.pdf

Their projection suggests that, by 2037, nearly 50% of existing jobs in this sector could be under threat due to increased automation. The impact of this phenomenon is particularly clear in countries like Cambodia, where garment production holds a dominant position within the manufacturing landscape; around 500,000 sewing machine operators could face with a significant risk of automation. Similarly, in Vietnam, a country with a notable presence in the manufacturing industry, the automation risk extends to nearly 800,000 workers (Chang & Huynh, 2016)[70]. As a result, the impact of automation can hit vulnerable segments of the population where apparel manufacturing is often the only livelihood for entire families.

Nevertheless, according to a PWC analysis conducted in 2017[71] is true that automation will lead to job losses in many industries, but, at the same time, new jobs related to these recent technologies will be generated. The affront of this wave of automation requires diverse governmental initiatives.

Firstly, public policy should be focused on investing in education and training for an automated world, by promoting a broad variety of career pathways and enhancing vocational training in STEM[72] (Science, Technology, Engineering, and Mathematics) disciplines that are less at risk of automation (PWC, 2017).

It is important that governments invest in education and training that will be most useful to young people in an increasingly automated world, and that training strategies are designed with businesses to ensure that the skills young people develop are relevant to an evolving workplace.

Secondly, governments in collaboration with educational institutions and local job centres, should provide career development opportunities, re-training support and upskilling programs for people affected or likely to be affected by job losses. These programs can help displaced workers to acquire new skills that align with emerging roles in the technology and automation sectors. Thus, in this current scenario, it is essential that governments could provide career advice

[70] Chang J./ Huynh P., 2016, ASEAN in Transformation: The Future Of Jobs At Risk Of Automation. International Labour Office, Bureau for Employers' Activitie ; ILO Regional Office for Asia and the Pacific. - Geneva: ILO.

[71] PwC. (2017). The $1.2 trillion prize from empowering young workers to succeed in an age of automation. PwC Young Workers Index. Pp 23, 25. Available at: https://www.pwc.nl/nl/assets/documents/pwc-young-workers-index-2017.pdf

[72] STEM is an umbrella term which encompasses the disciplines of science, technology, engineering, and mathematics. Primarily employed within educational policy and school curriculum decisions, this term holds significance for workforce development, national security considerations (given that a scarcity of STEM-educated individuals can impede effectiveness in this realm), and immigration policy, particularly about the admission of international students and technology professionals.

and retraining to those whose jobs are most at risk, with particular focus on those who are lower qualified, so that they can broaden their skill set and move into other roles and/or industries (PWC, 2017).

Thirdly, public policy should invest in R&D to create new job opportunities related to AI, automation, and technology. This might include roles in developing, maintaining, and improving automated systems.

Furthermore, the new automated technologies enable an increase in productivity which, in turn, results in an increase in gains. These extra incomes are spent and invested in turn in R&D, generating jobs and incomes across the economy (PWC, 2017).

However, balancing the advantages of automation and the fundamental rights of work, and manufacturing in particular, is still an issue to be discussed and solutions must take in consideration the needs of vulnerable communities, instead of simply replacing them with AI-powered machines.

Another critical issue concerns data privacy and security: most companies use systems based on artificial intelligence to collect, analyse, and store a large amount of customers' data with the purpose of learning about customers' habits, making prediction, and increasing sales though personalized advertising.

Data extracted from social media, data shared with reputable companies and collaborators, and procurement of this data from technology firms provide retailers and brands with insights that extend far beyond mere purchase records (Arnett, 2020)[73]. This data is harnessed to generate consumer scores via predictive analysis, forming the foundation for suggesting products and services aligned with individual customer profiles.

The acquisition and processing of this personal data (such as names, phone numbers, addresses, financial data, images, and other sensitive information) raise concerns regarding its

[73] Arnett G., 2020, What Fashion Retailers Know about You. «*Vogue Business*». Available at: https://www.voguebusiness.com/consumers/what-fashion-retailers-know-about-you-gdpr-farfetch-net-a-porter-matchesfashion-asos-john-lewis

usage and accessibility. In fact, main privacy concern revolves around the potential for data breaches and unauthorized access to personal information (The Economic Times, 2023)[74].

In 2018, the European Union introduced "The General Data Protection Regulation" (GDPR), which is considered the strongest privacy and security law in the world. This regulation imposes obligations for organizations and companies that collect, manage, and retain personal data within the EU, enforcing penalties against those who violate its privacy and security standards.

Therefore, the aim of the GDPR is to strengthen the protection of the personal data of European Union citizens, by giving them back the possibility to control over their personal information and harmonize privacy legislation within the EU.

One month after the implementation of GDPR, a Gartner survey revealed that almost one-third of European consumers claimed their privacy rights. This proportion was significantly higher than originally expected (Arnett, 2020).

Consequently, the collection and storage of customer data for AI-driven applications must align with regulations to guarantee the safeguarding of sensitive information against breaches or misuse.

This concern is also connected to consumer acceptance to embrace AI-driven fashion experiences, particularly from older generations or those who value the traditional shopping process. Consumers' perception about the use of artificial intelligence in fashion retail will be analysed in the last and fifth chapter, through the administration of a specific questionnaire to understand what consumers think of these recent technologies and how they live this change.

Another challenge of AI concerns the loss of human touch, meaning the possibility of AI contributing to a more standardized fashion landscape. The fashion industry is often associated with human creativity and artisanry, and overreliance on AI could lead to a loss of the human touch in design and production.

With AI algorithms driving design and production decisions, there is a risk that fashion may lose its unique and innovative touch. This scenario could result in a decrease in the quality of fashion items and a corresponding dip in the popularity of the overall industry. This is an

[74] The Economic Times, 2023, AI and Privacy: The Privacy Concerns Surrounding AI, Its Potential Impact on Personal Data. «*The Economic Times*». Available at: https://economictimes.indiatimes.com/news/how-to/ai-and-privacy-the-privacy-concerns-surrounding-ai-its-potential-impact-on-personal-data/articleshow/99738234.cms?from=mdr

authentic worry, underscoring the responsibility of the industry to guarantee that AI's use fosters both creativity and inclusivity (Forbes, 2023). The collaboration between human creativity and AI capabilities could facilitate the realization of this goal, resulting in the creation of unique and innovative works that may not be possible otherwise.

In conclusion, while AI offers several benefits to the fashion industry, it also comes with potential drawbacks that need to be carefully considered and managed to ensure a balanced integration that benefits businesses, workers, and consumers.

CHAPTER 3

The changing landscape of the retail sector

This chapter starts with an introduction of the retail sector and of its evolution through history to better understand the modern concept of Retail 4.0. Retailing is the last step in the value chain and represents the point where products are sold directly to consumers through different channels, such as physical stores, online stores, shopping centres and other outlets.

Following the focus will be on the fashion retail sector in particular. The analysis will consider the role of the COVID-19 pandemic in accelerating the growth of e-commerce in the fashion retail industry, as well as the significant role of AI in this changing and challenging landscape wthatcharacterizes the retail industry, in particular the fashion one.

3.1 The retail sector

Retailing can be defined as the set of activities which sale products or services in small quantities to consumers for their personal use or consumption (Newman & Cullen as cited in McCormick, H. et al., 2014)[75].

A retailer is an individual or business who purchases goods from manufacturers or wholesalers in bulk quantities at low price, and subsequently sells them in smaller quantities to end consumers, typically at a higher per-unit price (Retail Dogma, 2020)[76].

From the perspective of customers, the significance of the retail industry lies in its ability to offer convenience by catering to their everyday shopping requirements through various accessible channels (Retail Dogma, 2020). These channels can vary between brick-and-mortar stores, online platforms, direct mail, telephone sale, sale through print catalogues or direct sale.

According to The North American Industry Classification System (NAICS)[77], the retail sector comprises two main types of retailers: store and non-store retailers. Store retailers include

[75] McCormick, H., Cartwright, J., Perry, P., Barnes, L., Lynch, S., & Ball, G. (2014). Fashion retailing – past, present, and future. Textile Progress, 46(3).

[76] Mahmoud, R., 2020, What Is Retail? Definition, Business Model & Types. «*Retail Dogma*». Available at: https://www.retaildogma.com/what-is-retail/

[77] https://www.census.gov/naics/?input=44&year=2017&details=44

the normal brick-and-mortar stores, i.e., fixed point-of-sale locations designed to attract a high volume of walk-in customers. Retail stores, in general, have extensive item displays and primarily sell goods to the public for personal or household consumption, while some also cater to business and institutional clients as well.

Non-store retailers, like store retailers, serve the public, but their retailing methods differ. These retailers include e-commerce businesses, mail-order houses, selling from portable stalls (street vendors), door-to-door solicitation, in-home demonstration, vending machine operators and direct selling establishments.

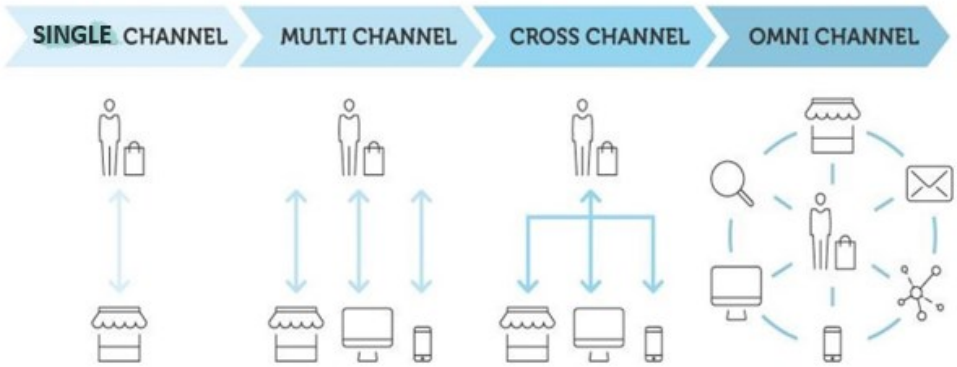
The retail store is particularly important as it serves as the bridge connecting the brand's identity with that of the customer. This space provides an opportunity for the brand to generate brand value and brand equity, thus encompassing not just economic aspects, but also fostering a relational dynamic with its clientele (Iannilli, 2019).

In fact, creating brand equity is essential for a brand as it refers to the process of establishing a positive and meaningful perception of a brand in the customer's mind. Brand equity centres on the customer, as its significance derives from the perceptions, emotions, memories, and connections that the customer holds with the brand. It encompasses emotional, psychological, and experiential aspects that contribute to a customer's loyalty, trust, and preference for a particular brand. On the other hand, brand value pertains to the monetary value of the brand and gauges its market worth (Aaker, 2022)[78].

In addition to the different sales channels mentioned above, retailers can use several types of business strategies to target consumers, including single/social channel, multi-channel, cross-channel, and omni-channel (as shown in Figure 4).

[78] Aaker, D., 2022, Brand Equity vs. Brand Value: What's the Difference? | Aaker on Brands. «Business Transformation Consultants | Prophet». Available at: https://prophet.com/2022/01/brand-equity-vs-brand-value/

Figure 3. The different types of business strategies used by retailers (Up-Biz, 2020)



Single channel refers to retailers who want to reach customers through a single-channel logic, regardless of whether it is online, catalogue, mail-order, face-to-face selling, or traditional retail through physical store. This approach reduces marketing investments and organizational complexity, but there is the risk to miss selling opportunities as customers nowadays use different channels to make their purchase (Lumen learning, 2020).

On the other hand, multi-channel retailing is a business strategy that combines different sales channels to accommodate where and how consumers make purchases (DANAconnect, 2021)[79]; each channel is independent, and customers can choose the one which suits their preferences. The most common types of sales channels typically include physical stores, online stores or ecommerce websites, third-party marketplaces such as Amazon, social media platforms such as Facebook Marketplace, and mobile applications for shopping on the go (Natarajan, 2019)[80]. In fact, one of the biggest benefits of this multi-channel strategy is the convenience it affords: it enables customers to shop at any time and from virtually anywhere. This means that consumers now purchase whenever it is convenient for them, whether at home, at work, or on the go.

[79] DANAConnect, 2021, Single-Channel, Multi-Channel, Omni-Channel or Cross-Channel. danaconnect.com Available at: https://www.danaconnect.com/single-channel-multi-channel-omni-channel-or-cross-channel-what-is-the-difference/

[80] Natarajan M., 2019, What Is Multi-Channel Retailing? | Definition, Benefits & Challenges - Zoho Inventory. «*Essential Business Guides*». Available at: https://www.zoho.com/inventory/guides/multi-channel-retailing.html

According to B. Batchelor (2023),[81] "the buying and selling of products and services through mobile applications, websites, and other devices - or mobile commerce (also called m-commerce) - is the future. And at least for now, it seems here to stay". According to Batchelor, m-commerce is a form of e-commerce that has emerged recently as an increasingly popular alternative for both retailers and consumers. Implementing a multi-channel strategy is essential nowadays for retailers to give the possibility to their clients to browse, swipe, click and buy products or services through their mobile devices.

Although multi-channel retailing is a beneficial strategy, there are a few aspects that businesses should consider before implementing it: difficulty in coordinating inventory across sales channels and expensive investment.

The complexity of controlling inventories across all the different sales channels is the biggest challenge in multi-channel retailing. This is since each channel is independent from the others, therefore a change in one channel will not be reflected in the others unless manually updated (Natarajan, 2019).

Furthermore, multi-channel retailing is expensive: planning to set up a lot of channels requires a large amount of money because each channel needs setup costs, customization, and recruitment of employees to manage it (Natarajan, 2019).

Another strategy is cross-channel retailing, that goes a step further from multichannel retailing, by emphasizing a unified customer experience across numerous channels. These multiple channels are no longer independent of each other but are linked in this strategy where the customer journey is harmonized too. Cross-channel strategy employs an interconnected approach to deliver a cohesive and unified experience across the consumer journey (Umesi, 2022)[82].

Unlike the multi-channel strategy that enables consumers to choose one purchase channel, cross-channel retailing gives customers the flexibility of completing their purchase across several channels (Davis, 2022).

[81] Batchelor B. Council Post: Shopping on The Go: 5 Strategies to Build a Strong M-Commerce Campaign. Forbes (2023). Available at: https://www.forbes.com/sites/forbesbusinessdevelopmentcouncil/2023/01/24/shopping-on-the-go-5-strategies-to-build-a-strong-m-commerce-campaign/?sh=4016420c7583

[82] Umesi, A., 2022, What Is Cross-Channel Marketing? Definition & Examples. *Careerfoundry.com*. Available at: https://careerfoundry.com/en/blog/digital-marketing/cross-channel-marketing/

Cross-channel strategy focuses on customer' experience, in fact it aims at the integration and continuity of different channels to offer a better, a consistent and more fluid customer experience. Moreover, it promotes the growth of consumers' engagement, regardless of if they interact with the brand through physical stores, websites, mobile apps, social media, or any other touchpoint (Davis, 2022).

Some examples of this strategy are engaging consumers in social media to redirect traffic to the website, geo-localized advertisements or click&collect services which allow customers to buy online and pick up in the physical store.

Cross-channel marketing is expensive and can be challenging since it turns a basic and simplified customer journey into something much more intricate and complex. When creating a cross-channel plan, it is essential that campaigns work together across the different channels to increase the probability that the target audience engages with the brand and makes purchases (Marketing Evolution, 2022)[83].

Another strategy is the omni-channel retailing which takes cross-channel to the next level as it is entirely centred on the customer.

While cross-channel retailing enables customers to use several and connected channels to complete a purchase, omni-channel strategy offers a total channel integration, providing customers with a seamless buyer experience, with personalized channel content updated in real time based on their activity (Davis, 2022). With cutting-edge technologies such as artificial intelligence and machine learning which are able to collect data related to customers' behaviours and preferences, omnichannel strategies enable to interact with consumers in a relevant, timely and personalized way.

In this approach the customer experience is simultaneous across all different channels and touchpoints, with retailers offering seamless operations across all of them and uniting the physical, digital, and mobile experiences (Iannilli, 2019).

In other words, an omni-channel strategy prioritizes the customer as the focal point of a continuous, complete, and consistent communication experience, regardless of the channel via which they connect (DANAconnect, 2021).

[83] Marketing Evolution, 2022, Cross-Channel Marketing: Tips & Examples to Guide Your Strategy. Available at: https://www.marketingevolution.com/marketing-essentials/cross-channel-marketing

The omni-channel approach is a truly relevant discussion in retailing nowadays; the rise of m-commerce and e-commerce, both in terms of the number of users and commercial websites, has considerably increased the importance of the omnichannel approach in the retail industry.

The modern consumer lives through technology and constantly seeks different channels to use simultaneously for shopping, in an interchangeable and complementary way, without interruptions. In this scenario, the omnichannel approach has become a crucial strategy for retailers to remain competitive and provide customers a seamless, personalized, and engaging experience as they move between offline and online channels.

3.2 The evolution of retailing

Retailing is known since antiquity and has changed significantly over time in tandem with the emergence of transportation, technology developments and shifts in culture.

The technological revolutions of the 20th century had a significant impact on civilization and retailing experienced a series of significant changes as well; this included an acceleration of processes and cost-effectiveness, which raised rivalry and competition among the entrepreneurs (Gladchenko, 2023)[84].

In the 21st century, in particular in the last decade, retailing has changed staggeringly due to the raise of e-commerce which led to a dramatic increase in the number of consumers who shop online through computers and mobile devices. As a result, retailers improved and still are improving their online presences, integrating traditional brick and mortar with e-commerce experiences for the consumers (Sularia, 2023)[85].

In addition to this big shift, the arrival of the COVID 19-pandemic has forced even more companies to adapt to a remote, digital-first approach to survive such a complicated and challenging time.

[84] Gladchenko A., 2023, Evolution of Retail Industry over One Hundred Years. *GEPARD*. Available at: https://gepard.io/insights-trends/evolution-of-retail-over-one-hundred-years

[85] Sularia S., 2023, Council Post: Retail Evolution through the Digital Decade: Three Factors Impacting Retail Today." *Forbes*. Available at: www.forbes.com/sites/forbestechcouncil/2023/02/02/retail-evolution-through-the-digital-decade-three-factors-impacting-retail-today/?sh=2ca030e37241

The retail sector fully supported big transformations through history and industrial revolutions, the spread of the Internet and the rise of e-commerce, and COVID 19 pandemic are some examples; this highlights the great flexibility and resilience of this sector.

Since when people exist, they have been sharing, bartering, selling, and consuming resources. As early 9000 BC, nomads exchanged sheep and cows in trade. People used to trade through barter until 3000 BC when Mesopotamia introduced the first proper currency (Meyer, 2019)[86].

The first open-air public markets became known in ancient Babylonia and in Egypt. Typically, these open-air markets were in centre of the town where skilled workers and artisans, such as leather workers and metal workers, prepared goods to sell on market days (Bhasin, 2019)[87].

As time progressed, this tradition evolved and found its way in ancient Greece by 800 BC, where Agora was the place where the markets operated in an open-air space; in market days the goods were on display for the people (Meyer, 2019).

Between the 9th and 10th century BCE, the Phoenicians emerged as major trading power. They were specialized in the importation and exportation of commodities and products such as textiles, wood, dry fruit, oil, wine, and nuts (Bhasin, 2019).

As history progressed into the Roman era, open-air markets continued to develop and thrive. These markets were mostly served by local peasants and poor producers who sold a small surplus their farming activities for their livelihood and to purchase small equipment and farm tools (Bhasin, 2019).

However, making a big time jump forward, it is from the second half of 1800's that modern retail really took off (Meyer, 2019).

The modern concept of retail was born with the emergence of shopping arcades in the late 18th century in Europe which then evolved into the known department stores. The first department store in the world was founded in Paris by brothers Paul and Justin Videau in 1838 and was called

[86] Meyer S., 2019, The History and Evolution of Retail Stores (from 1700s to 2020). The BigCommerce Blog. Availabel at: www.bigcommerce.com/blog/retail/

[87] Bhasin, H., 2019, Complete History of Retail Industry and the Future of Retail Industry.*Marketing91*. Available at: https://www.marketing91.com/history-of-retail/

"Le Bon Marché"; however, in 1852 it was completely revamped by Aristide Boucicaut, a French entrepreneur, thanks to whom Le Bon Marché became the first modern department store.

In this period, in addition to the department stores, were still quite common classic stores, i.e., small, family-owned independent businesses, also called "mom-and-pop". These stores were drug stores or general stores that offered merchandise that could be bought for daily life, from groceries and fabrics, to clothing, tools, and toys (Meyer, 2019).

Starting from 1870, the world experienced the Second Industrial Revolution, which continued until 1945. Those years were protagonists of a period of significant technological advances, such as Ford automobiles and electric railway systems which improved the logistics within retail operations. Furthermore, inventions like the bulldozer[88], accelerated the construction of shopping arcades and supermarkets.

Starting from the first decades after the World War I, the retail sector began to undergo another a significant evolution. In 1916 in Memphis (USA), Clarence Saunders brought into life the first self-service grocery store, often referred to as a supermarket where people could directly choose products from shells without the help of a salesperson. Few years later, this first grocery eventually expanded into the first true supermarket chain, "Piggly Wiggly" (Gladchenko, 2023).

With these innovations, people were more interested and more eager to buy, having the opportunity to touch and experience the products.

In 1920, the retail industry underwent further transformations due to big shifts in social relationships and cultural values. People desired to be free of the constraints of the past, prompting business and advertising to respond to the updated expectations of consumers by providing a more liberal purchasing experience. Moreover, those years saw the birth of modern marketing, which played a crucial role in meeting and influencing customers' needs (Gladchenko, 2023).

World War II inevitably reduced global commerce sales; yet the end of the conflict marked a new stage in the world's economy development. Technologies such as the airplane and automobile became more widely available, contributing to the post-war growth of retail trade.

[88] A bulldozer is a large and motorized machine equipped with a metal blade to the front for pushing material like soil, sand, rubble, or rock during construction work.

In the first decade after the war, while the popularity of supermarkets was expanding, the concept of a "shopping mall" was conceived and brought to life. The first indoor shopping mall opened in Minnesota in the United States (Meyer, 2019).

The growth of shopping malls was driven by two main factors: the first one is related to shifting consumers' behaviour during the 1950' and 1960's when shopping evolved from a mere necessity into a form of entertainment; the second one is correlated with the grow of automobiles. As more people started purchasing cars, they became more motivated in leaving cities to reach the suburbs where shopping malls were located. These malls were often anchored by a large department store with a cluster of other stores around it.

It is also important to mention that between 1940s and 1960s there were a series of technological innovations which paved the way for a new phase in retail. Transistors, which transformed electronics, were followed by colour television, microwaves, and IBM's introduction of the hard drive in 1954. These advancements provided retailers with a wide range of products to offer to their customers to satisfy their evolving needs and desires (Gladchenko, 2023).

Since 1962, the first "big boxes", such as Walmart, Kmart, and Target, began to spread. Big boxes are large stores that serve bigger populations and provide items cheaply at a much bigger scale. The efficiency and overall size of these indoor giants made them attractive to consumers looking for convenience (Meyer, 2019). Big boxes offer a wide range of products, from clothing, shoes, sporting goods, jewellery, health and beauty products to toys, food, drinks, and hardware appliances, books and so on.

The year 1970 is marked as the start of the Information Age (also known as Computer Age or Digital Age). In 1971, the first Intel microprocessor[89] was invented, having the capacity to transform the whole economy of that age. This techno-economic paradigm let the retail gradually step into the age of computerisation (Gladchenko, 2023).

By the 1980's, PCs began to spread on a large scale; companies like IBM and Apple launched personal computers that helped bring computer technology to homes and offices around the world.

[89] A microprocessor is a small chip considered as one of the most important computer components. The function of this component is to perform a large number of high-speed calculations.

Between the 1990-2010s online shopping becomes a reality. The introduction of the Internet and later of the high-speed Internet connection DSL, caused a new era in the retail industry.

The year 1995 marked the emergence of important e-commerce companies, such as Amazon that first launched an online bookstore, and E-bay that launched an online platform for selling and buying second-hand products.

In the same year, The Secure Socket Layer (SSL) protocol was developed to provide safe data transmissions, privacy, authentication, and integrity over the Internet, in order to make the online shopping experience safer for consumers. In 1998 PayPal introduced the online payment systems, and shopping through a PC became even more convenient.

During the first decade of the 21st century, thousands of sellers and retailers have jumped onto the ecommerce bandwagon (Meyer, 2023). Some of them, such as Etsy, Groupon, and Jet.com, have evolved into enormous online markets, opening new opportunities for both individual buyers and ambitious enterprises.

The rise of ecommerce paralleled the rise of the internet. As more people gained access to the digital world, their interest in purchasing online grew. Moreover, e-commerce enhances the buying experience by allowing customers to research, read reviews, compare prices, and make purchases at any time of the day.

The growth of the Internet accelerated in the following years, having a significant impact on society, including shopping habits. Nowadays sellers have the possibilities to advertise and sell their products or services through social media, such as Facebook, Instagram, WhatsApp, Twitter and Tik Tok. E-commerce and mobile commerce have empowered consumers, as they can now research and select products online, compare prices and quality online. At the same time marketers and retailers analyse the customers' data to provide them tailored product recommendations and advertisement (Gladchenko, 2023).

Nowadays it is possible to talk about retail 4.0, a term used to describe the digitization of the physical shopping experience through the integration of new retail and data capture technologies. In fact, using recent technologies, such as AI-powered systems, retailers can study customers' data to provide them products in the most efficient, effective, and personal manner possible. This is possible by offering a seamless customer journey in stores and online through an omni-channel

approach and by providing AI-based tools to improve the online shopping experience (Santaella, 2020)[90].

If today is possible to talk about retail 4.0 is because this industry has come a long way over the years, adapting to changing consumer preferences, to the rise of digital shopping platforms, to the emergence of AI-based technologies, and in recent years to the arrival of the Covid-19 Pandemic. As retailers morph and evolve to keep up with innovation and challenges, at the same time, they drive new customer behaviours, ushering in the next era of retail history (Meyer, 2019).

3.3 AI's supportive role in online fashion retail during the COVID-19 pandemic

In the fashion retail industry, e-commerce was already a consolidated pillar of fashion shopping, but its raise in the last years has been significantly accelerated by the COVID-19 Pandemic.

As other industries, also the global fashion industry has been affected by the COVID-19 pandemic because governments closed manufacturing plants, stores, and cancelled fashion events with the aim of slowing the spread of the virus. This prompted consumers to look for online alternatives to meet their purchasing needs; online shopping became a safer and more convenient option to buy products without having to physically go to stores. This change in consumers' habits caused a sudden and massive shift towards e-commerce platforms, forcing retailers to adjust their e-commerce strategies and implement new ones based on AI technologies, to navigate these challenges and continue serving and satisfying customer demand.

Although e-commerce was already established as a fundamental element in the field of online shopping for many years, it has recently embarked on a transformative journey to recreate, using artificial intelligence technologies, interesting experiences, and sensory stimuli that customers used to encounter in brick-and-mortar stores. In this sense, AI allows to enhance the

[90] Santaella E., 2020, Understanding Retail 4.0 & the Digital Transformation. Mobile Insight. Available at: https://mobileinsight.com/understanding-retail-4-0-digital-transformation/#:~:text=Essentially%2C%20Retail%204.0%20is%20the,retail%20and%20data%20capture%20technologies

entire e-commerce shopping experience by adding a touch and feel experience (Pillarisetty & Mishra, 2022)[91].

In fact, it is true that shopping online is very convenient, but at the same it has several limitations. The big barrier remains the lack of possibilities to physically touch, feel, see, and try on clothes, as well as the lack of shopping experience (Jeferson, 2016)[92].

Despite the advantages of e-commerce, such as saving times, cost efficiency, improved logistics and open return policies, some shoppers are still hesitant to buy without first having a tangible experience.

The absence of touch-feel-try raises worries about the quality and wearability of a garment or accessory. Furthermore, traditional shopping offers a sensory experience in the form of a show-room ambience, smart sales attendants, scents, and sounds that cannot be experienced online (Jeferson, 2016).

On the other hand, there are consumers who are completely open to the idea of online shopping, but they would derive greater satisfaction from an elevated and improved experience.

This is where artificial intelligence may help, by offering consumers a purchasing experience that closely resembles the in-store one (for example, virtual clothes try-ons) or an extremely tailored buying process supported by virtual style assistants or chatbots. These AI-based technologies have the potentiality to become a widespread technology for online retail issues, as they will be extremely useful in replicating a sensory purchasing experience online (Silvestri, 2022).

Thus, the key issue will be to reinforce and implement AI technologies on e-commerce websites, as they are becoming increasingly important as shopping channels, particularly during and after the pandemic where the shift to online shopping was exacerbated (Silvestri, 2022). In fact, according to Statista (2023), in 2022 retail e-commerce sales were estimated to exceed 5.7 trillion U.S. dollars worldwide, and this figure is expected to rise further in the next years.

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[91] Pillarisetty R./Mishra P., 2022, A Review of AI (Artificial Intelligence) Tools and Customer Experience in Online Fashion Retail. «International Journal of E-Business Research», vol. 18, no. 2. Available at: https://www.igi-global.com/article/review-artificial-intelligence-tools-customer/294111

[92] Jeferson, 2016, Advantages and Disadvantages of Online Shopping. «Money Matters | All Management Articles». Available at: https://accountlearning.com/advantages-disadvantages-online-shopping/

As a result, the role of AI in online fashion retail during the pandemic has been critical, accelerating changes that would have otherwise taken years to materialize. This convergence of artificial intelligence with pandemic-induced difficulties has resulted in a paradigm change, redefining how fashion retailers operate and interact with customers.

AI technologies have the potential to become the norm in the fashion media and technology ecosystem in the near future, strengthening the industry's digitization process and enriching the customer’s shopping experience (Silvestri, 2022).

In conclusion, the pandemic highlighted the urgency of implementing AI technologies in e-commerce to ensure business continuity in an era of unprecedented challenges. In synergy, this intricate interplay between AI's capabilities and the pandemic's disruptions has underscored the sector's resilience and adaptability, charting a course toward a technology-driven future where the fusion of innovation and real-world challenges propels the fashion retail landscape into uncharted territories.

CHAPTER 4

AI and digital technologies applied in the fashion retail sector

As already mentioned, one of the main obstacles concerning online fashion shopping is the lack of the shopping experience and physical interaction with products.

However, with the development of digital technologies, such as augmented reality (AR) and technologies based on artificial intelligence, the customer shopping experience can be improved and enriched.

This chapter analyses the most common AI technologies used in the online fashion retail which make the customer shopping experience more engaging; these include virtual try-on, chatbots, virtual style assistants, personalized product recommendations and visual search.

Following, the chapter analyses the so-called "smart mirrors," mirrors based on AI technology that will be applied in physical stores in the near future.

For each of these recent technologies, a case study will be presented.

4.1 Virtual try-on

Fashion clothing requires a multisensory input, and it has been demonstrated that the lack of direct experience may result in less consumer engagement in the shopping process (Blazquez, 2014). However, with the development of virtual-try on, also called virtual fitting room, this multisensory input can now be recreated in the online environment.

The online shopping experience differs from the physical stores' one. Online stores offer convenience in term of time and physical travel, cheaper prices and a wider choice of products which facilitate the buying decision process (Zendehdel, 2015)[93]. Nevertheless, it does not offer the possibility to see the product, touch with hand the fabric and test the quality, as well as to try on clothes, shoes, and accessories to verify if they truly fit the style and body of a person.

[93] Zendehdel M./ Hj Paim L./ Osman S.B., 2015, Students' online purchasing behavior in Malaysia: Understanding online shopping attitude. «Cogent Business & Management», vol. 2, no. 1. Available at: [PDF] Students' online purchasing behavior in Malaysia: Understanding online shopping attitude | Semantic Scholar

This can be considered as a disadvantage for e-commerce because the sensorial experience is not as rich as in a physical store. But, through the implementation of artificial intelligence and digital technologies, such as AR, in the field of online retail, companies can provide customers with a similar experience that they would have in-stores (California Apparel News, 2019).

In this sense, technology is blurring the boundaries between the in-store and online shopping experiences, creating an engaging and interactive online experience for customers (Blazquez, 2014).

An example is the virtual try-on, the digital version of an in-store dressing room, which allows customers to virtually try on clothes, accessories, and shoes, to visualize how they may look on their bodies. This is possible by using digital devices, such as smartphones, tablets, and computers. Nevertheless, this function is still little used in practice, as it is under development and improvement.

Virtual try-on can also be implemented through online avatar creation: customers provide their body measurements and size, resulting in the creation of an avatar or 3D model that accurately reflects their physical proportions. This avatar functions as a virtual mannequin for trying on clothing, shoes, and accessories. Some fashion brands, such as Zara, have already adopted this technology.

Virtual try-on systems help users to assess the fit, the size and the look of the product, but at the same time they reduce the perceived risk of buying a product without first try it on, consequently reducing the risk of returns and refunds (Pillarisetty & Mishra, 2022).

Virtual try-ons use artificial intelligence and augmented reality (AR) to recreate the dressing room experience digitally.

Augmented reality is a technology based on the integration of virtual information with the real world (Lamantia, 2009), in particular with the user's environment in real time. Unlike Virtual Reality (VR), which generates a completely artificial environment, users of Augmented Reality (AR) encounter a real-world environment with digital information superimposed on top of it (Gillis, 2022).

Augmented reality is used to either aesthetically alter natural environments or to give users supplementary information. The fundamental advantage of AR is that it blends digital and three-dimensional (3D) components with an image of the real world in real time. In other word, it

creates an immersive scene mixing the virtual and the physical world, by overlapping digital objects that interact with the real world.

Virtual try-ons, not only use AR to virtually show customers how the product would look on them, but they also use artificial intelligence, in particular Computer Vision and Machine Learning, to improve the customer shopping experience; the combination of these two tools based on AI can scan people's bodies to recommend the correct size and the best look according to the body shape.

It is important to mention that artificial intelligence and AR are distinct technologies, but they can work together to provide even more immersive experiences.

Virtual try-on has grown in popularity in recent years, notably in the beauty sector, with brands such as Sephora, MAC, Yves Saint Laurent Beauty, investing in technology to allow customers to try on cosmetics by uploading a picture or live video.

Many fashion brands, such as Adidas, Asos, Crocs, Gucci, Nike, and Timberland, have understood this potential and are investing in providing virtual try on into their online shops. According to 3D Look (2022), virtual fitting rooms will be a must-have for fashion retailers, even if for now many brands are only testing them for a small number of lines of clothes, sneakers and accessories.

4.1.2 Case study: Adidas

In November 2019, Adidas launched, in its IOS app, the augmented reality feature to let shoppers virtually try on its most iconic shoes models and its recent line of running shoes “Alpha Edge 4D running”.

To use the AR feature, mobile users need to download and open the Adidas app and then click on the shoe models that support this function. To offer an immersive 3D view, a virtual version of the shoes will appear on the user's feet following its movements in real time.

The goal of this Adidas's new virtual try-on feature is to help customers to pick out new shoes styles without physically going to a store, as well as to give them a better idea of how the shoes will look on their feet before buying them online (see Figure 4.1).

To launch this feature, Adidas has partnered with Vyking, an AR try-on technology company specialized in AR solutions for e-commerce and digital retail. Inside Adidas’ app, Vyking’s

software[94] can track customers' foot movements, making the virtual try-on experience run in real-time with or without your shoes on.

The CEO of Vyking, Matthew Klimpke, said: "We are excited to launch AR try-on in the Adidas iOS app. Partnering with Adidas has allowed us to roll this feature out alongside the much-anticipated Adidas Alphaedge 4D release and a selection of the Originals range. Viewing products in 3D is already known to increase conversions and we are anticipating a big increase in conversions through our footwear try-on technology." This partnership with Adidas has been really rewarding in our push to provide meaningful innovation through our AR technology. Our team of researchers, software developers and e-commerce experts has built a state-of-the-art AR try-on solution that completely reshapes how you shop for shoes online and in the retail stores of the future[95]."

With this statement, Matthew Klimpke highlighted the fact that the motivation for footwear brands and e-commerce platforms to invest in this technology is to increase sales and margins, as well as to improve the customer experience, increase conversations, reduce returns, and attract new customers.

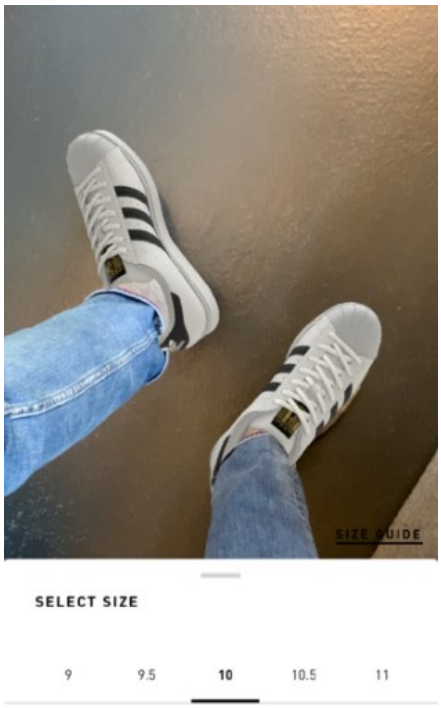
In addition to Adidas, other brands have also invested in implementing virtual try-ons in their online and physical stores. For instance, in the same year, Rival Puma opened its first North American flagship store in New York where AR-based experiences were a central feature. Gucci added AR to its iOS app allowing customers to virtually try on their Ace sneakers. Similarly, Nike's app allows shoppers to scan their feet using a smartphone camera to receive customized shoe size recommendations.

AR is still an experimental technology, and many brands are currently testing it to prepare themselves for a future when AR experiences will become commonplace. For now, this technology is being adopted especially in the beauty industry more than fashion, where most of the main brands have all adopted makeup virtual try-on in their websites. Fashion has been using it still on an experimental level or as a special feature.

[94] https://www.vyking.io/shoes

[95] Perishable. Adidas AR Sneakers Try-On App. Virtual Reality Marketing, 2019. Available at: https://www.virtualrealitymarketing.com/case-studies/adidas-ar-sneakers-try-on-app-2

Figure 4.1 Adidas virtual try-on based on AR (Adidas app)



4.2 Chatbots

According to Accenture (2023), around 80% of CEOs wants to update their customers' interaction through conversational tools. Two different conversational solutions exist for the companies: chatbots and intelligent virtual assistants. In this paragraph the functionality and the types of chatbots will be described. Chatbots can be divided into two types:

1. Rule-based chatbots

Rule-based chatbots, also called click bots, are based on predefined conversational paths where users get predefined question and answer options. Unlike an AI based chatbot, this type of chatbot is not able to answer a question which is outside these pre-designed questions as it does not have Machine Learning ability (Sinch Engage, 2023).

In other words, rule-based chatbots follow a predefined set of rules and instructions, and they typically provide responses that are tightly structured and determined by those rules; this means that their responses are limited to what has been explicitly programmed into their rule sets. Not having the ability of Machine Learning, they do not possess the power to adapt or learn from user input beyond what is specified in their rule-based system.

Rule-based chatbots are often employed in customer service scenarios to provide quick answers to frequently asked questions (FAQ) and to help users to find useful information quickly without the need of calling a real agent.

2. AI chatbots

AI Chatbots are computer programs equipped with artificial intelligence, designed to interact with users through text or voice-based conversations, simulating a dialogue with a human being. In particular, AI chatbots employ a variety of AI technologies, such as Machine Learning (ML) that optimizes responses over time, Natural Language Processing (NLP) and Natural Language Understanding (NLU) that accurately interpret and answer fluently to user questions. Deep learning capabilities are also important, as they allow AI chatbots to become more accurate over time, which in turns allows humans to interact with AI chatbots in a more natural, free-flowing way without being misunderstood (IBM, 2023)[96].

Unlike a rule-based chatbot, an artificial intelligence bot, which employs ML, NLP and NLU, can respond to human input even when it deviates from a pre-programmed script; in this sense, it is able to conduct intelligent conversations with customers, answering to questions that have not been predefined.

AI Chatbots are powerful tools capable of understanding human language, generating automate timely and relevant responses to user inquiries, solving problems, and providing information without the need for human intervention or manual research (IBM, 2023).

Concerning the fashion retail field, AI chatbots can be implemented through a variety of communication channels, such as messaging apps like WhatsApp or Facebook Messenger that have both released instant message tools specific for businesses, but also mobile app, social media apps, websites, email, and SMS.

AI chatbots are very useful tools for fashion brands: first, they can provide customer service support 24/7 to answer customer queries and resolve common issues, such as sizing, returns, and shipping without the need for a human operator; secondly, some chatbots can act as virtual stylists, helping customers put together outfits and offering fashion advice. This can increase cross-selling and upselling opportunities for fashion brands. Thirdly, AI chatbots can engage with

[96] IBM. What is a chatbot? (2023). Available at: https://www.ibm.com/topics/chatbots

customers through conversational marketing, sending personalized promotions, notifying customers about new arrivals or sales, and assisting in the purchasing process directly within the chat. Finally, AI chatbots can be integrated with various messaging platforms and social media channels, allowing fashion brands to reach customers where they are most active; in this sense chatbots can enhance the omnichannel presence of the brands. This possibility to chat with brands through different channels is extremely attractive, especially for younger audiences who are used to communicate mostly through online messaging platforms. In fact, according to Open Market (2016)[97], over 60% of millennials would like to be able to talk to brands via texting; this data underscores the importance for brands of investing in this medium.

A chatbot is a strong medium for the online fashion retail as it fills the gap between customers and online retailers, allowing them to connect with each other (TNS Expert, 2023); that is why many popular fashion brands have implemented them. Asos with its fashion bot "Enki" offers personalized fashion recommendations and assists customers in finding clothing items based on their preferences and style. H&M uses an AI chatbot which helps customers find products, provides fashion advice, and answers general inquiries on their website and app. Tommy Hilfiger has been one of the ground breakers in the chatbot universe implementing a Facebook chatbot in 2016 which provides style tips and product recommendations to users, enhancing the online shopping experience. Victoria's Secret has implemented a chatbot that suggests new collections by the brand. The Burberry chatbot offers the possibility to browse the current collections and get complete looks with the chatbot suggesting matching items and accessories.

It is important to mention that these fashion chatbots are not available in every country. Mostly of them are only available in the USA and in UK. Nevertheless, the adoption of chatbots is growing globally and it is expected that, in the near future, they will be increasingly widespread in Europe and in the rest of the world.

[97] OpenMarket (2016). OpenMarket's Survey Reveals Texting is the #1 Preferred Channel for Two-Way Business-to- Millennial Communications. Retrieved from https://www.openmarket.com/ press/millennials-prefer-sms-business-notifications/

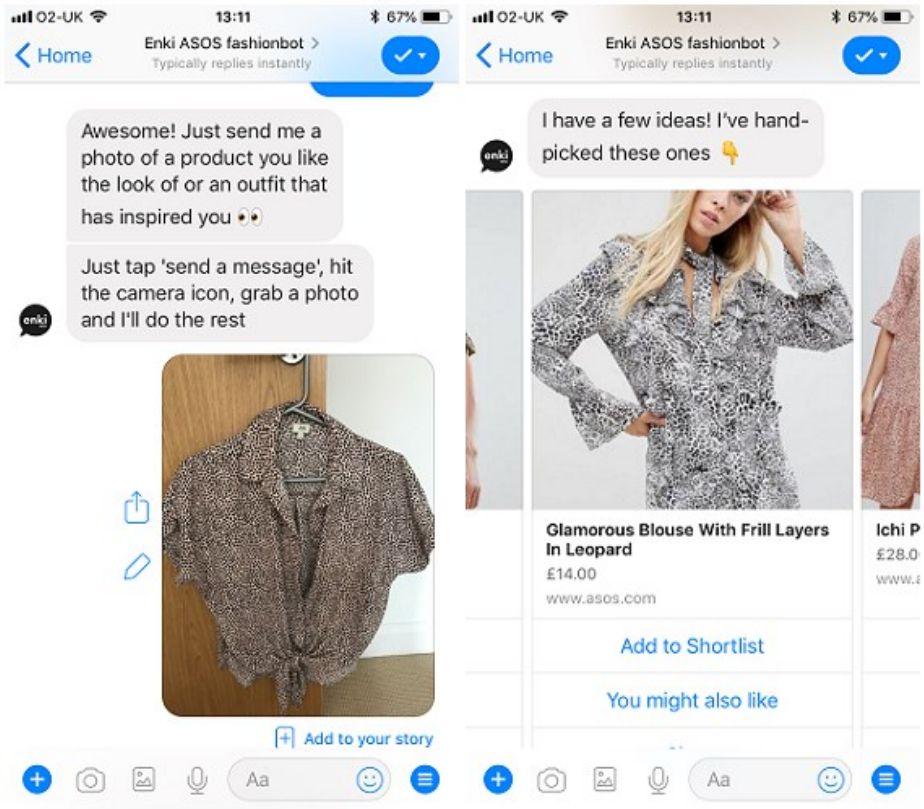
4.2.1 Case study: ASOS

E-commerce brand ASOS developed in 2018 its chatbot called Enki available on Facebook Messenger. It offers UK customers a more personalized experience by helping them to discover new products and recommending items they might like (as shown in Figure 4.2).

The goal of Enki is to encourage users to experience ASOS in a more engaging way. This is possible through its 'Style Match' technology, which allows users to search for related items like the ones they already like; the user can upload a picture of a particular garment on Enki and the bot will suggest similar products (Gilliland, 2018)[98].

This is the same technology used for ASOS' "visual search" feature on the brand's app, which is available in every country, including Italy. The visual search feature will be analyzed in the next paragraphs.

Figure 4.2 Interactions with ASOS' Enki chatbot (Gilliland, 2018)



[98] Gilliland N., 2018, Why ASOS' Enki has set the bar for retail chatbots. Retrieved from https://econsultancy.com/why-asos-enki-has-set-the-bar-for-retail-chatbots/

Enki also enables users to add fashion products to “your shortlist” or click on “you may also like” to see other similar examples. In this sense Enki works both as a chatbot and as a personal style assistant that actively searches for accurate items on user’ behalf.

Another benefit of Enki is a greater personalisation, as the chatbot can also recommend items tailored to the user's individual fashion preferences based on information on past purchases and browsing history (Gilliland, 2018). Of course, customers with an account who regularly buy from ASOS can fully reap these benefits.

Regarding the actual chat element, ASOS has chosen to avoid free-form text, mostly asking users to select between the proposed options. This means that even if a user types a question or an answer, the bot will not answer, but will provide an option to the user to click.

When launched, the bot was in beta version and the brand encouraged users to leave feedback to help the company improve the algorithm. As of today, it is unclear in which stage the development of the technology is, but if ASOS were able to enhance its chatbot and scale it to more users, this could be a game changer in the fashion industry, as a chatbot able to be activated by voice, text and photo is a unique and powerful tool.

The brand claims it will keep working on Enki and is making efforts to extend its availability to more countries. In fact, as much as chatbots in conversational commerce[99] had theirs promising days and many companies resorted to this tool, in the fashion industry its uses are still very limited.

ASOS' Enki serves as a significant case study since the company successfully has crafted a highly interactive bot, equipped with several features that enhance the overall user experience. If the company continues to refine and expand this tool to encompass other countries and product categories, it could establish a model for other fashion brands to recognize the extensive possibilities offered by chatbots in conversational commerce.

[99] Conversational commerce is e-commerce done via various means of conversation such as live support on e-commerce Web sites, online messaging apps such as Facebook Messenger and WhatsApp, chatbots on messaging apps or websites.

4.3 Virtual style assistants

Stylists are experts in the fashion industry who curate outfits for various purposes. In fact, they are professionals who can work for private clients, brands, magazines, retailers, and high fashion roles by providing advice on style, fashion trends and clothing choices. Fashion stylists generally select clothing and accessories that are on-trend for a given season while ensuring that all choices match a model's or client's body type, lifestyle, and aesthetic profile.

However, artificial intelligence has made possible the automation of styling assistance, making it more accessible and affordable to a broader audience. This transformation is renewing the traditional fashion industry, creating new opportunities for both consumers and businesses.

A virtual style assistant (also called fashion chatbots or fashion style assistants) is an AI-powered application that helps users to find products aligned with their style or with current trends, recommend garments and accessories that match their body type or advise on how to exploit better the user's current wardrobe.

In other words, AI style assistants are designed to help users to improve their style by giving them personalized recommendations based on data. In fact, AI style assistants use a combination of Machine Learning (ML) and Natural Language Processing (NLP) to provide personalized fashion recommendations, wardrobe management, and style advice.

Machine Learning algorithms are employed to create recommendation systems that analyse user data, including clothing preferences, purchase history, and interaction history; these algorithms learn from this data to make personalized fashion recommendations.

Natural Language Processing, on the other hand, is used to create chatbots that allow users to interact with the virtual style assistant through natural language. In fact, a virtual assistant is usually integrated into a chatbot, where users can ask questions, seek fashion advice, and receive responses.

Virtual style assistants differ from chatbots because they offer a more immersive and dynamic customer experience compared to traditional text-based assistance The assistant has the ability to recognize the clothes that customers have in their online cart, to understand their style preferences, and to consider their past purchase history. By leveraging this information, the virtual assistant is able to suggest products that have a high probability of being compatible with the users' taste.

Virtual assistants, as chatbots, are powerful tools which can enhance the user shopping experience by giving them personalized and unique style advice; however, their diffusion in fashion retail is still limited to beta version in countries such as US and UK and is still under development.

4.3.1 Case study: Zalando

Zalando, a leading European online platform for fashion and lifestyle based in Germany, is looking to enhance the online fashion shopping experience with the launch of the beta version of a virtual style assistant. It will be powered by ChatGPT across their app and web platforms and will be available to selected customers in Germany, Ireland, the UK, and Austria by spring[100] (Zalando, 2023)[101].

The new fashion assistant will allow customers to navigate through Zalando's assortment using their own words or fashion terms and providing them with relevant suggestions in an intuitive and natural way (see Figure 4.3).

In fact, according to Zalando, if a customer asks: "What should I wear for a wedding in Santorini in July?", the virtual assistant will be capable of understanding the fact that it will be a formal event, that it will be a sunny day, and therefore it will provide a written text with recommendations for clothing based on that input (Zalando, 2023).

With its answers, Zalando's fashion assistant will provide customers with relevant products, allowing them to have ongoing chats to optimize their results. This technology will introduce a new way to discover Zalando's assortment, providing customers with more intuitive fashion inspiration (Zalando, 2023).

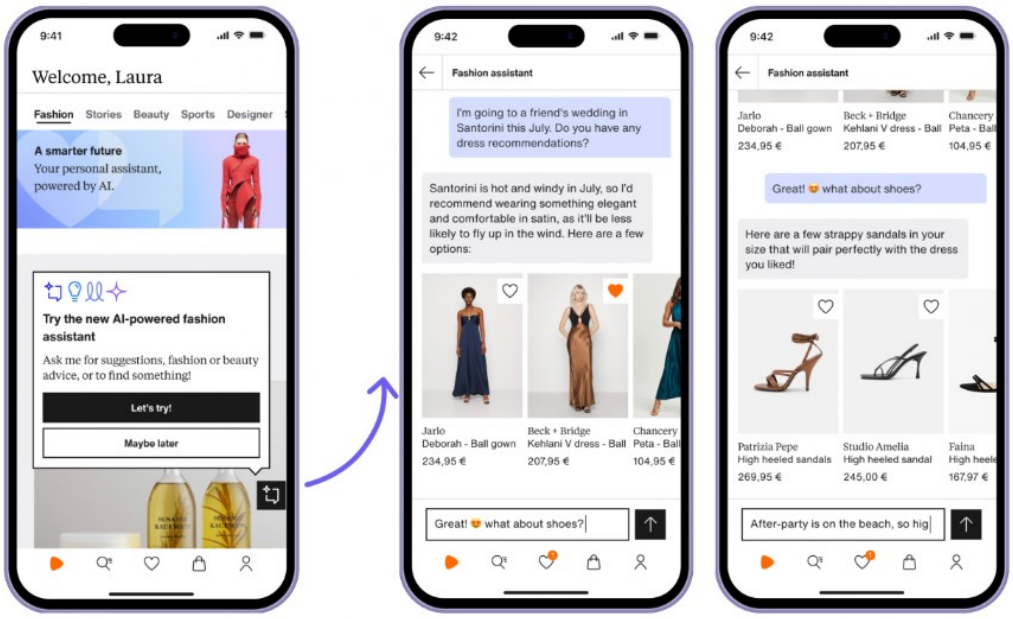
With the imminent launch of the first version of its fashion assistant, Zalando is laying the framework for future developments and features, which could include fashion and beauty advice or outfit design. With its fashion assistant, Zalando's goal is to build a trusted companion for its

[100] In the article the year of the launch is not specified, but since the article was published in April 2023, the launch of this tool is intended for 2024.

[101] Zalando, 2023, Zalando to Launch a Fashion Assistant Powered by ChatGPT." *Zalando Corporate Website*. Available at: https://corporate.zalando.com/en/technology/zalando-launch-fashion-assistant-powered-chatgpt

clients which includes privacy and AI protection in line with Zalando's commitment to providing a trustworthy experience (Zalando, 2023).

Figure 4.3 Zalando's virtual style assistant (Zalando)



4.4 Personalized product recommendations

AI-based recommendation systems are commonly used in fashion retail e-commerce and are a crucial component of the modern online shopping experience. These systems in particular use Machine Learning algorithms to suggest products to users based on their browsing and purchase history, preferences, behaviour, and demographic information. The recommendation system leverages AI to analyse customer data, find patterns and trends in their purchasing behaviour and recommend products that they are likely to be interested in. This improves customer satisfaction and increases sales by providing personalized recommendations tailored to each customer's specific needs (Prijic, 2023)[102]. In this sense, recommendation systems are incredibly useful as

[102] Prijic M., 2023, Top Use Cases of AI-Based Recommendation Systems.IT Convergence. Available at: https://www.itconvergence.com/blog/top-use-cases-of-ai-based-recommendation-systems/#:~:text=AI%2Dbased%20recommendation%20systems%20are,history%2C%20preferences%2C%20and%20behavior

they help users to discover products they might otherwise have not found on their own. Delivering the most suitable products to customers, precisely when they need them, fosters tailored experiences, ultimately resulting in increased sales.

For fashion stores, implementing product recommendations not only drives sales and increases the average order value (AOV), but can also enhance the shopping experience for customers. This undoubtedly strengthens engagement and fosters customer loyalty, ensuring their return to your store (Wandawa, 2023)[103].

Three types of recommendation systems exist: collaborative-based filtering, content-based filtering, and hybrid. Collaborative-based filtering displays items to a shopper based on data on what other similar users have purchased. In other words, it recommends items to users based on the preferences of other users who are similar to them. Content-based filtering looks at the similarities between items to recommend other items similar to the user's preferences. Hybrid combines collaborative and content-based filtering approaches (Wandawa, 2023).

Since all these categories rely on data-driven methods and employ Machine Learning techniques, the relevancy of the product recommendations is extremely high.

Unlike the other AI-based instruments analysed in the previous paragraphs, personalized product recommendations are widely used by e-commerce companies and by online fashion retailers all around the world.

These systems have become increasingly popular in the fashion industry because they can improve the customer shopping experience and drive sales. By analysing customer behaviour and preferences, fashion brands can provide personalized product recommendations, making it easier for customers to discover items they are likely to be interested in. This personalisation has the potential to raise client satisfaction, engagement, and sales conversion rates.

[103] H. Wandawa (2023). The Best Product Recommendation Strategies For Fashion Stores. Boost Commerce. Available at: https://boostcommerce.net/blogs/all/best-product-recommendation-strategies-for-fashion-stores

4.4.1 Case study: Shein

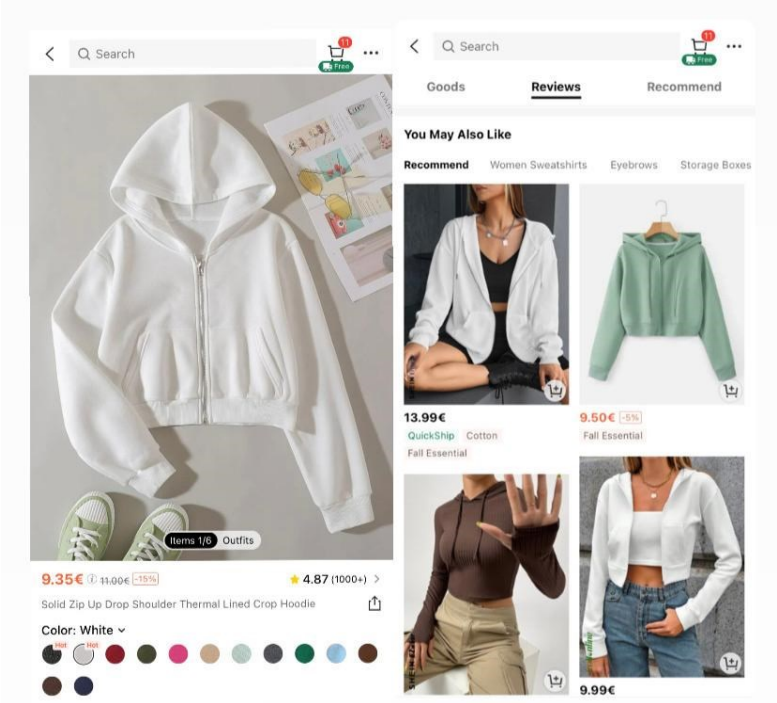
The Shein app experience is more a recommendations feed driven to product discovery, rather than an experience driven primarily by research. Chinese mobile e-commerce is an environment where recommendation traffic far exceeds search-driven traffic. The strong dependence on recommendation with respect to research is a common thread running through the world of the Chinese mobile internet. As a result, there is a huge pool of experience built around the recommendations in e-commerce.

Personalized product recommendations on Shein, or on any other e-commerce platform, are designed to increase sales and enhance the shopping experience for users by suggesting products that they are likely to be interested in.

When users first sign up in Shein app, the platform starts collecting data about their behaviour and preferences, which include information such as the most viewed, searched and added to their cart products, as well as their demographic information, location, and browsing history. Through Machine Learning algorithms, Shein analyses this data and build users' profiles; based on the user's profile, then the algorithms generate personalized product recommendations. For example, if a person frequently browses for "women's dresses" and has purchased similar items in the past, the system will recommend more dresses that match that style and preference.

Furthermore, the recommendation system continuously updates its recommendations in real-time while users interact with the app. In fact, if a user searches for a specific product or clicks on a recommendation in the section "you may also like," the system takes that into account and adjusts its suggestions accordingly (see Figure 4.4).

Figure 4.4 Shein personalized product recommendations (Shein)



4.5 Visual search

Visual search in fashion online shopping refers to the use of visual search technology to help users find clothing and accessories that match their preferences by using images as input. This technology leverages Computer Vision and Machine Learning algorithms to analyse and recognize the visual characteristics of items within images or photographs, subsequently recommending similar or related products from an online retailer's inventory.

To use virtual search users can either upload an image from their device or take a photo of a clothing item they like. This could be something they see in real life or a picture from a magazine, social media, or another website. The visual search technology analyses the uploaded image, identifying key features like colour, pattern, style, and shape. Based on the analysis, the system searches and presents a list of clothing and accessories that are visually similar to the item in the uploaded image. Users can click on these recommendations to view more details, check availability, and make a purchase.

This tool is very powerful as it enhances the user shopping experience online, making it easier for shoppers to find products they like.

Visual search is disrupting the world of retail and many fashion brands, such as Zara, H&M, and Asos, have already implemented it in their apps.

4.5.1 Case study: H&M

H&M is a famous fashion clothing chain based in Sweden. Founded in 1947, H&M has become one of the largest retail fashion companies in the world.

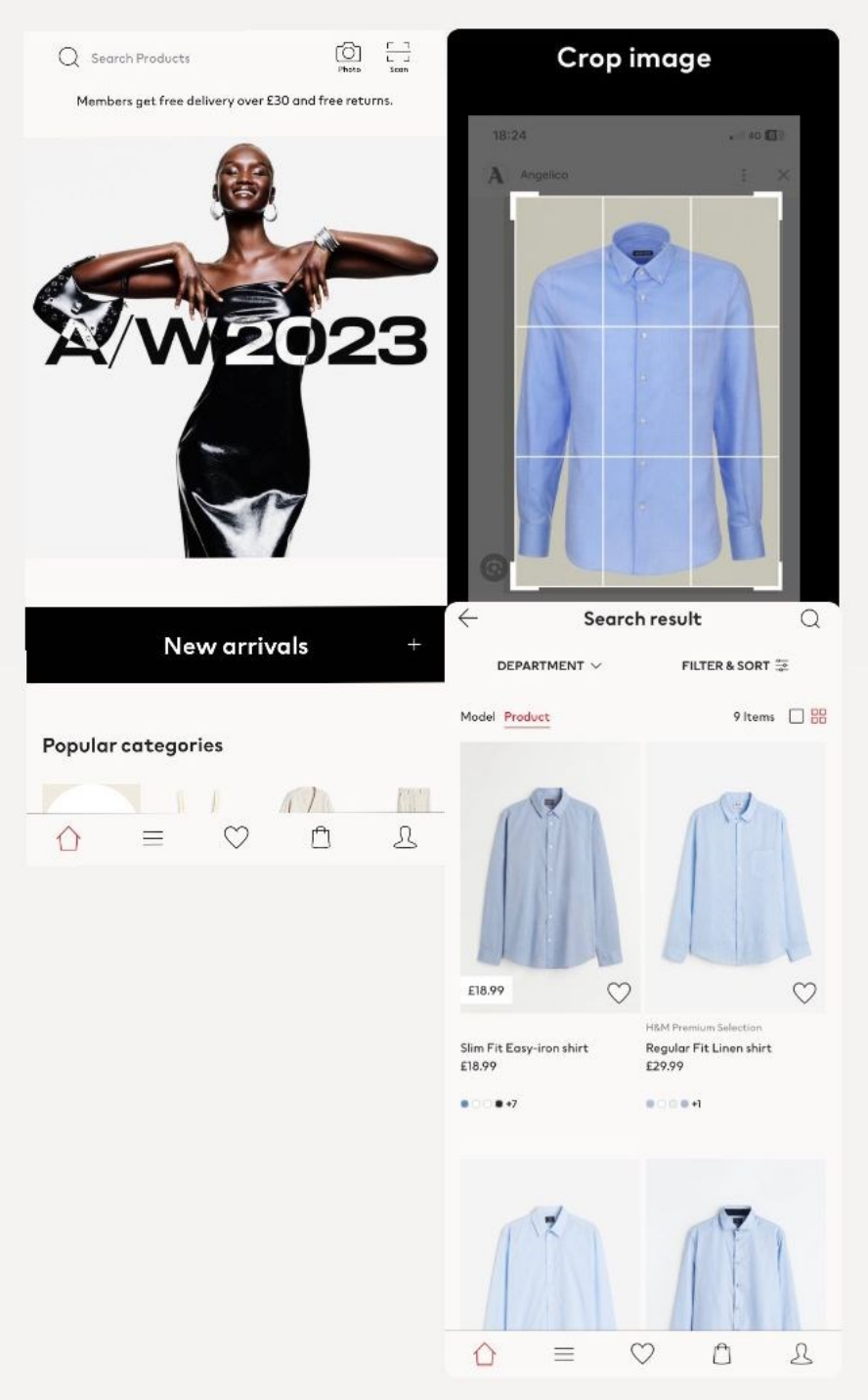
In 2017 H&M came with the new feature of "visual search" for U.S. shoppers allowing them to search for products by uploading a photo (Wilson, 2018)[104]. Nowadays this feature is available in many European countries, including Italy.

To use this feature, it is sufficient for the users to download and open the H&M app on their smartphone. Then tap the camera icon on the top right corner and snap or upload a photo from their library. Finally tap search to upload their photo to see a list of similar or matching items in stock at H&M (see Figure 4.5).

The advantages for H&M to implement this technology into its app are to enrich the user shopping experience and increase conversion rates: in fact, visual search enables customers to discover products they may not have found using traditional text-based search, and at the same time it can help improve conversion rates as customers are more likely to make a purchase when they quickly find products that match their preferences or the items they have seen elsewhere.

[104] Wilson M., 2018, H&M Launches New Online Site with Visual Search. Chain Store Age. Available at: https://chainstoreage.com/technology/hm-launces-new-online-site-with-visual-search

Figure 4.5 Visual search in H&M app (H&M)



4.6 Smart mirrors in brick-and-mortar stores

Although online retail sales have been growing in the last years, physical retail still has a significant role in people's purchasing habits. In fact, according to a study of Fashion United. com (2018)[105] made on fashion shoppers in the USA, "brick and mortar stores still take a bigger piece of the cake, with 75% of all fashion purchases being made in physical stores".

The brick-and-mortar retail store serves as a space where the brand can create stories to establish emotional connections with customers, providing an environment for amusement, gaming, and experimentation (Iannilli, 2019). By offering an immersive experience that goes beyond the sale of products, physical retail stores can attract back customers, by giving them the possibility to engage with innovative and captivating technologies, such as smart mirrors, for instance.

Smart mirrors (also called magic mirrors) are interactive and technologically advanced mirrors equipped with various features beyond their traditional reflective function. These mirrors incorporate digital displays, sensors, connectivity, and software to offer an interactive and innovative shopping experience. Smart mirrors also include a camera that together with the digital screen, provides the reflection of the user, which in reality is a real-time image captured by the camera.

Smart mirrors are based on a combination of Computer Vision algorithms (Luce, 2019) and AR technologies. Computer vision algorithms are useful to process and analyse visual data, which may include recognizing users, identifying gestures, and tracking movements. Computer Vision enables the mirror to understand the context and the user's actions. On the other hand, AR overlays digital information, such as virtual try-ons of clothing or makeup, onto the real-time reflection of the user. With this feature, customers can try clothes, shoes, and accessories in-store digitally, being able to change outfits and try assorted colours within seconds, just clicking on the mirror and without having to visit the changing room (Ferrandez, 2022) [106].

[105] Elven M van. 75 percent of fashion purchases made at physical shops. but people spend more online. fashionunited.com. (2018). Available at: https://fashionunited.com/news/retail/75-percent-of-fashion-purchases-made-at-physical-shops-but-people-spend-more-online/2018060821670

[106] Ferrandez C. Why magic mirrors are the future of in-store retail. Poplar Studio (2022). Available at: https://poplar.studio/blog/magic-mirrors-smart-mirrors-are-the-future-of-in-store-retail/

In this sense, the idea of a smart mirror is similar to the virtual try-on that retailers implement in their apps; however, a smart mirror is a real physical tool which can be placed inside brick-and-mortar stores, providing an interactive and immersive experience for customers.

Moreover, smart mirrors can display additional information, such as product details, pricing, and availability. Customers can interact with the mirror's touchscreen interface to access this information and make informed purchasing decisions.

According to Ferrandez (2022), there are other benefits that smart mirrors can offer to customers; first they do not have to visit the fitting room or queue for it, offering a faster and more convenient shopping experience. With magic mirrors, in fact, customers do not have to queue to use the fitting room, nor are they limited by how many items they can try on at a time. Second, they solve stock-out problems by allowing customers to try on items that are not available in-store. In fact, for whatever reason, brick-and-mortar stores may not always have a brand's full product catalogue in stock. This can be often disappointing for customers.

Brands can benefit too from the adoption of smart mirrors: first, they can improve the customer experience. Modern consumers are looking for experiences to share and tell and retailers can meet these consumer needs by incorporating this innovative interactive and social tool. Secondly, they can reduce returns. Whether because fitting rooms are full or customers simply do not want to try on items before buying them, returns are a big problem for retailers. However, through streamlining the try-on procedure, smart mirrors have the potential to decrease the volume of returns that brands must manage. Thirdly, they can boost sales. For instance, if a product is currently unavailable, customers can virtually try it on and arrange for home delivery once the item is restocked in-store. Moreover, certain smart mirrors can suggest alternative or complementary products, offering brands another way to upsell or cross-sell to customers (Ferrandez, 2022).

In conclusion, smart mirrors are not only functional, but also aesthetically pleasing, making them a unique and innovative addition to retail stores. In fact, they can bring the testing and gaming aspect that can make physical retail more attractive to consumers, especially for digital natives.

Although these mirrors are not yet widespread, they will be an experiential game changer and will positively improve the user shopping experience in the physical stores.

4.6.1 Case study: H&M

Swedish fashion retailer H&M Group starting from May 2022 is expanding its range of technology-enhanced shopping experiences at its Cos stores in the United States. These advancements encompass intelligent mirrors that offer individualized style advice and the opportunity for virtual outfit try-ons (Wright, 2022)[107].

This expansion comes after a successful trial at its store in Beverly Hills, where fitting rooms featured smart mirrors capable of recognizing items brought in (including details like item, size, and colour) and offering personalized product and styling recommendations (see Figure 4.6).

The H&M Group stated that "The entire retail experience is rapidly changing, and we see increasing customer expectations for broad choice and exceptional convenience. Our customers expect retail experiences that are smooth, creative, and fun while also catering to their individual, unique style. That is why we continue to challenge ourselves and explore new ideas, to create true customer value and drive change". From these words, it is possible to understand that the launch of the new in-store technology-based shopping experience for H&M is part of its wider aim to build more relevant and meaningful relationships with consumers (Wright, 2022).

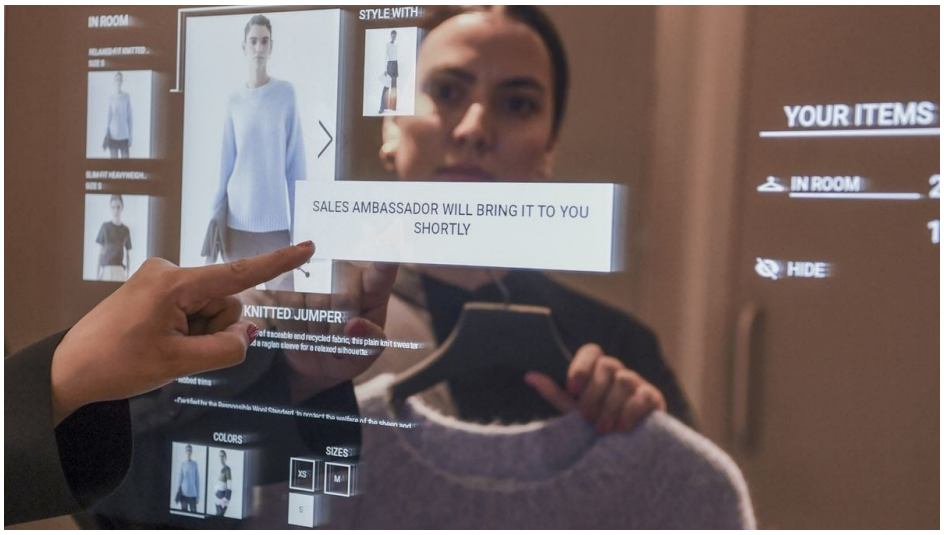
This is not the company's first foray into smart mirrors. H&M piloted voice interactive mirrors in 2018 at its New York City location in Time Square, which also provided styling recommendations, discounts via QR codes and selfies. To create the mirrors, the retailer tapped Microsoft, Ombori, a UX design company, and Visual Art, a digital signage company.

For now, H&M is developing and imagining how COS retail spaces can inspire their customers, both now and for the future. Their ambition is to pilot modern technologies that allow to meet and exceed their customers' in-store shopping expectations (Morris, 2022)[108].

[107] Wright B. H&M Group pilots smart mirrors in Cos US stores (2022). Available at: https://www.just-style.com/news/hm-group-pilots-smart-mirrors-in-cos-us-stores/

[108] Walk Morris T., 2022, H&M Tests Smart Mirrors at COS Stores in a Bid for a More Personalized Experience. Retail Dive. Available at: https://www.retaildive.com/news/hm-tests-smart-mirrors-at-cos-stores-in-a-bid-for-a-more-personalized-expe/625014/

Figure 4.6 H&M smart mirror in Beverly Hills, California



CHAPTER 5

Field research: AI in fashion retail and consumer's perception

This fifth and final chapter presents the empirical research that has been planned and conducted with the aim of investigating the opinions of a sample of consumers regarding the use of AI-based technologies in the fashion retail sector.

The methodology chosen will be explained first, followed by the statistical analysis of the collected data and by a summary of the major findings.

5.1 Methodology

The research on consumers' perception regarding the use of AI-powered technologies in fashion retail has been conducted in the field through the administration of a specially designed questionnaire to a sample of Italian consumers. In particular, the aims have been to investigate the opinions of respondents on online and in-store shopping, the opinions on AI technologies during shopping, and the degree of concern about the use of these technologies. The technologies considered are those analysed in Chapter four: virtual try-ons, chatbots, virtual style assistants, personalized product recommendations, visual search and, smart mirrors. To ensure clarity, a brief explanation of these technologies was provided in the questionnaire, as not all respondents could be necessarily aware of these definitions.

The objectives

The objectives of the empirical research can be detailed as follows: investigating and highlighting people's perception of AI technologies, assessing the level of exposure to these current technologies, and exploring the major concerns among respondents, such as privacy and the security of personal data, which could alienate consumers from the option of online shopping. The focus is restricted to Italian consumers.

The final goal is to gain insights into Italian consumers' perspectives on the use of these technologies in the fashion retail sector, with a particular focus on their concerns in order to provide a potential future scenario that envisions how artificial intelligence, the fashion industry, and consumers can coexist harmoniously.

The questionnaire

The questionnaire has been prepared in Italian (see Annex 1), given the intention to investigate Italian consumers' perceptions and opinions, and it is divided into four sections.

The first section includes five questions (I/1-5) to collect data useful to get a personal and professional profile of the interviewees.

The second section consists of thirteen questions (II/1-13) and focuses on the evaluation and opinions that respondents have regarding fashion shopping, both online and in-store.

The third section includes sixteen questions (III/1-16) and is dedicated to gathering the respondents' opinions on AI technologies while shopping. The fourth and final part, which consists of eleven questions (IV/1-11), is dedicated to investigating the degree of respondents' concern towards the use of these technologies during online shopping.

The questionnaire consists of 45 questions, including yes-or-no questions, very brief open-ended questions, questions requiring a rating on a scale from 1 to 10, and multiple-choice questions that call for reflection and selection among different options.

The questionnaire was prepared and administered through the Google Forms tool. This choice was motivated by the agility of online administration that, indeed, allowed to reach a sample of 190 people from various Italian regions in a limited time span.

The sample

Due to the limitations of this research in terms of resources and access to the population, probabilistic sampling, which ensures that every individual in the population has the same probability of being selected for the study, was not possible. Thus, non-probabilistic sampling was used, specifically convenience (or accidental) sampling. This sampling technique involves selecting individuals who are easy for the researcher to reach and contact.

Although this sampling method often provides bias due to the limited nature of respondents, it also offers advantages in terms of time, reduced costs, and easy accessibility to the target population. However, it is important to clarify that, due to the sampling used, the results of the survey are not representative of the entire clothing consumption population. Nevertheless, the obtained results can provide valuable first insights into the current AI landscape in fashion retail.

More precisely, the questionnaire was distributed during the final week of September through three social media channels: Instagram, WhatsApp and Facebook. On Instagram, a story on my account was posted with a link to the questionnaire while asking my followers to fill it for my research. On WhatsApp, a link was shared with people I knew aged between 18 and 58 years old, and on Facebook a status was posted with the link attached, asking people to fill it. Additionally, efforts were made to broaden the reach by requesting friends and family members to share the questionnaire link with their respective networks, primarily through Instagram and WhatsApp.

The final sample consists of 190 people, 131 women and 59 men, living in Italy and belonging to three different age groups corresponding to Generation X, Y, and Z.

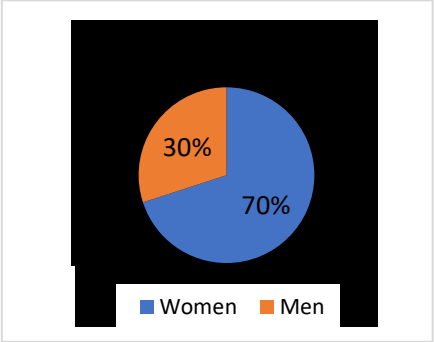
5.2 Data analysis

Below the data collected from the administration of the questionnaire to the sample of respondents will be presented, articulating them in the sections in which the questionnaire can be divided. The analysis of the questions will be supplemented with graphs for a more immediate reading of the data, which will also be briefly commented.

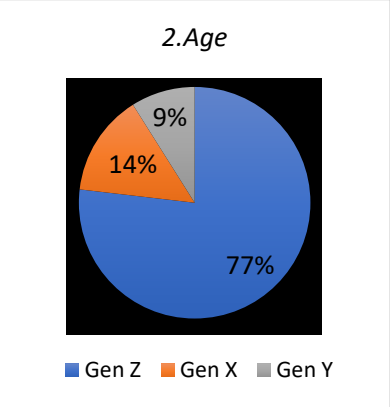
5.2.1 Personal profile of the interviewed sample

The first section aims to outline the statistical aspect of the sample of 190 respondents, with respect to variables such as gender, age, region of birth, education, and occupation.

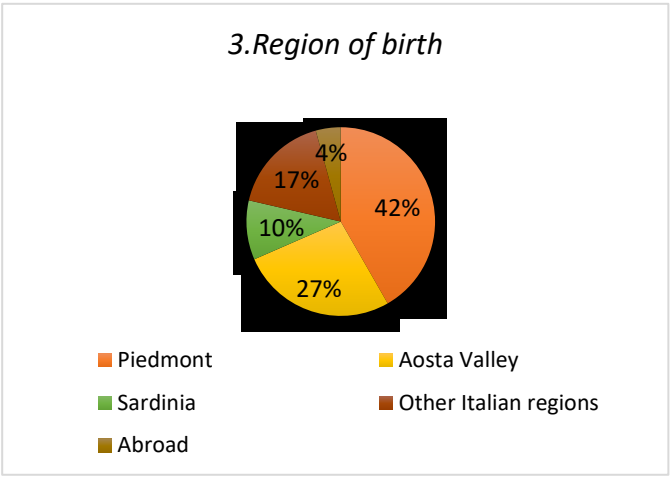
In terms of gender *(1. Gender),* women represent 70% of the sample, for a total of 131 women, while men represent 30% of the sample for a total of 59.



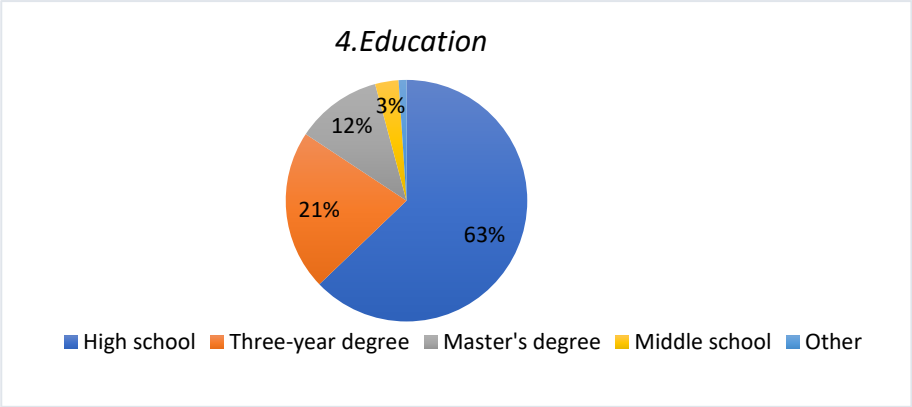
With regard to age (*2. Age*), respondents can be classified into three distinct age groups corresponding to Generation X (born between 1965 and 1982), Y (born between 1983 and 1994), and Z (born between 1995 and 2005). Generation Z is the predominant one (77%) with a total of 146 respondents; followed by Generation X (14%) with 27 respondents, and Generation Y (9%) with a total of 17 respondents. The average age of the total sample is 27.6 years. Although I personally contacted older people via Whatsapp, contacting people between the ages of 35 and 58 years was more challenging, than contacting people of my age. In fact, concerning the age, in the sample there is a polarization towards younger people belonging to the Z generation, due to the ease of access to people who are about my age.



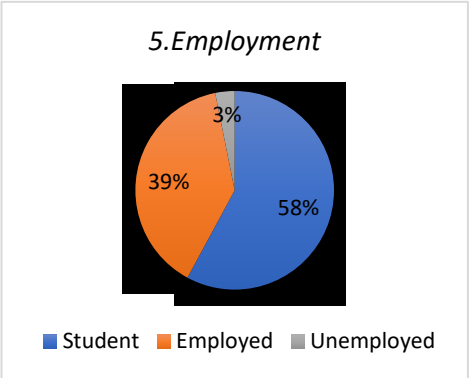
Regarding the region of birth (*3. Region of birth*), the majority of the respondents were born in Piedmont (42%) for a total of 78 people; followed by Valle d'Aosta (27%) for a total of 50 people, and Sardinia (10%) with a total of 19 people. The remaining 17% of respondents come from other Italian regions (including Abruzzo, Calabria, Campania, Lazio, Liguria, Lombardy, Molise, Puglia, Sicily, Tuscany, and Veneto), while 4% were born abroad, but currently living in Italy.



When analysing the education level of the interviewees (based on question *4. Education*), the majority (63%) hold a high school diploma, while 21% have a three-year degree, 12% possess a master's degree, 3% attended middle school, and 1% selected “Other”.



With regard to employment status (*5. Employment*), the majority of the participants are students (58%), 39% are currently employed, while only 3% are unemployed.



The sample composition in terms of profile (with a prevalence of female, Gen Z, people from Piedmont and Aosta Valley and students already holding a high school diploma) is likely due to the sampling method and the procedure used to distribute the questionnaire.

5.2.2 Opinions on online and in-store shopping

The second section of the questionnaire is designed to explore respondents' purchasing habits, including the frequency of monthly online and in-store purchases, as well as their preferences for each of these two shopping modes.

For question 1, *"Have you ever bought clothes, shoes, or accessories online?"*, nearly the entire sample (92%), which corresponds to 182 people, answered "Yes", while only 8% reported that they had never shopped online.

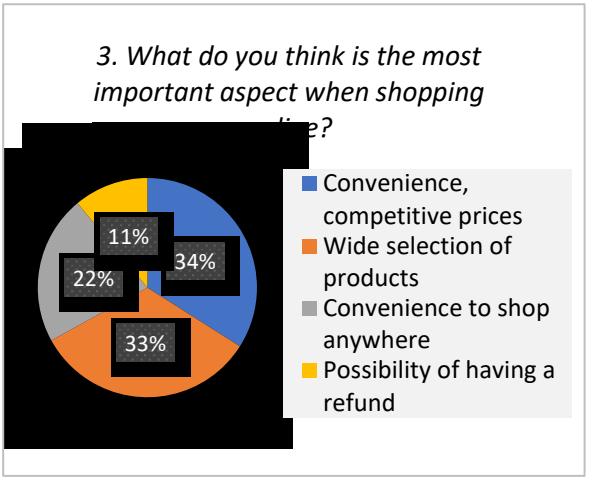
This question has been cross-referenced with the age of the interviewees to understand if there are significant differences based on age regarding online purchases.

It might be expected that a significant proportion of individuals within the Generation X cohort, comprising those aged between 40 and 58, would fall among the 8% who have never shopped online. This expectation arises from the perception that Generation X, having not grown up as digital natives, would likely exhibit a preference for the conventional in-store shopping experience, to which they may be more accustomed. However, empirical data contradicts this expectation, revealing that 23 out of the 27 individuals belonging to Generation X (85%) have shopped online on at least once. This data underscores the fact that online shopping is not exclusive to younger demographics, but also extends to individuals of more mature age groups.

To further test this hypothesis, the statistical test was conducted using the IBM SPSS STATISTIC platform, to verify if the two variables (age and online purchases) were indeed unrelated. Indeed, the statistical test revealed a non-significant relation (>0.5).

For question 2. *"How often do you buy clothes/accessories online on average in a month?"*, 61% reported shopping *rarely*, meaning less than once a month; 35% mentioned shopping *occasionally*, which equates to once or twice a month; 3% indicated shopping *often*, approximately once a week, and only 1% reported doing it *very often*, more than once a week. It is worth noting that this question was answered exclusively by those who responded "Yes" to Question 1, which accounts for 92% of the respondents.

In response to question *3. "What do you think is the most important aspect when shopping online?",* the majority (34%) answered "convenience and competitive prices", followed closely by 33% with "a wide selection of products", 22% with "convenience to shop anywhere", while a minority corresponding to 11% of respondents indicated the "possibility of having a refund" if the purchase is not satisfactory as the most important aspect.



In summary, it is possible to affirm that the most important aspects for respondents during online shopping are the possibility to make purchases at lower and cheaper prices compared to traditional stores, which generally have higher operating costs leading to higher prices, and the possibility to choose from a much broader selection of products than what physical stores typically offer.

On the other hand, when respondents were asked about the aspect they liked least about online shopping (Question 4. *"What is the aspect you least like about online shopping?"),* the majority (73%) expressed dissatisfaction with the inability to physically try on clothes and accessories. This was followed by 17% who disliked the inability to assess fabric and quality, 6% were not fond of the return and refund policies (which entail printing the return label, going to the post office, and waiting for a refund), and 4% were unhappy with delivery times, which could vary in duration.

In response to question 5. *"How often do you buy clothes/accessories in physical stores on average in a month?"* most of the sample (55%) reported shopping *rarely*, meaning less than once a month. Additionally, 39% mentioned shopping *occasionally* (once or twice a month), 3% admitted to shopping *often* (once a week), 2% *never* shop in physical stores, and the remaining 1% do it *very often* (more than once a week).

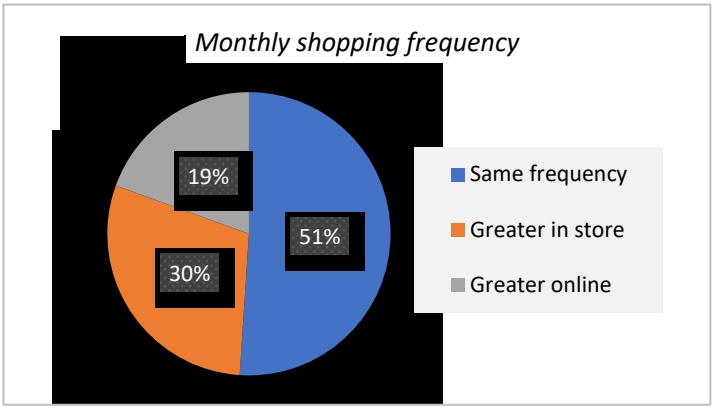
These results, which closely resemble those of question 2. *"How often do you buy clothes/accessories online on average in a month?"*, highlight a certain uniformity in consumer behaviour regarding monthly purchases. In fact, respondents, whether making online or in-store purchases, tend to shop rarely, less than once a month.

Subsequently, the individual responses of the interviewees to question 2 *("How often do you buy clothes/accessories online on average in a month?"*) and question 5 (*"How often do you buy*

clothes/accessories in physical stores on average in a month?") were jointly analysed to investigate whether the monthly shopping frequency for each interviewee is the same, greater, or lesser in the two shopping modes. The data revealed that, for the majority of the interviewees (51%), the frequency is the same. This data suggests that these individuals shop online and in physical stores with the same frequency in a month. For example, a person who *occasionally* shops online will also do so in physical stores with the same frequency.

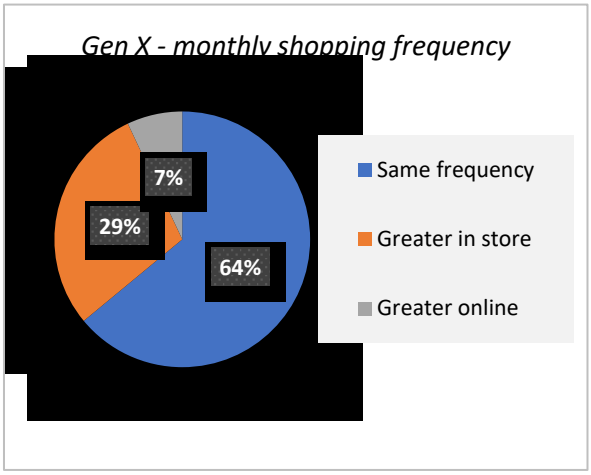
For 30% of the sample, the purchasing frequency is not the same but is greater in physical stores. This data indicates that these individuals shop in physical stores more frequently than they do online. For instance, if a person *occasionally* shops online, they will do so *more often* in physical stores.

For the remaining 19% of the sample, the purchasing frequency is greater online. This data indicates that these individuals shop online more frequently than in physical stores. For example, if a person *occasionally* shops online, they will *rarely* do in physical stores.



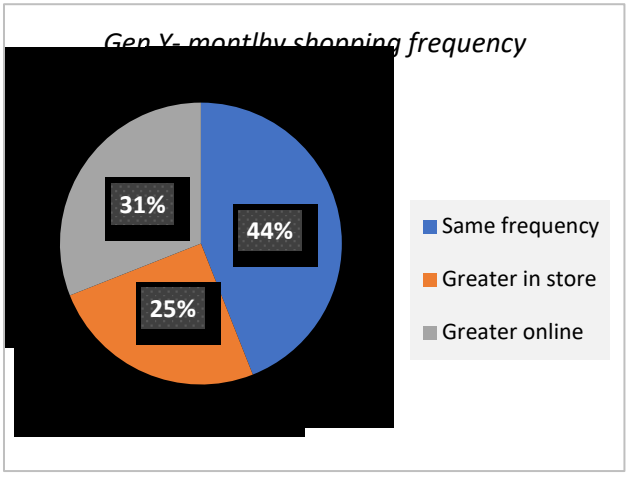
Another interesting aspect is to compare the monthly purchase frequency among the three different generations to determine if there are any variations in buying habits based on age.

Regarding Generation X, it is evident that the majority of participants (64%) make purchases with the same monthly frequency, whether online or in-store. This data suggests that individuals from Generation X shop both online and in physical stores with equal frequency within a month.



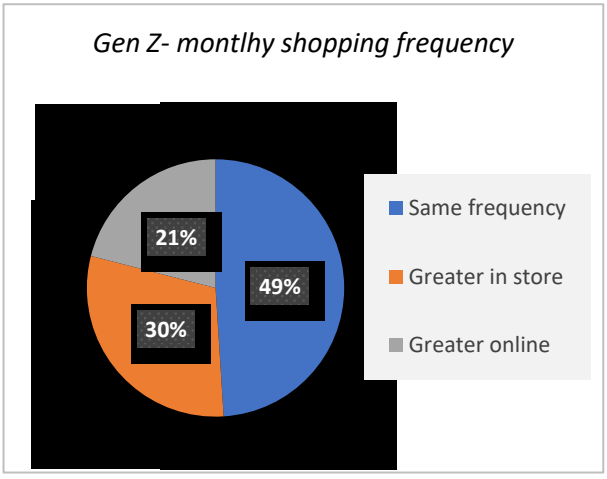
Among the respondents from Generation X, 29% exhibit a greater purchasing frequency in physical stores, indicating a preference for in-store shopping. In contrast, the remaining 7% have a higher purchasing frequency online, indicating a preference for online shopping.

In Generation Y as well, the majority of participants (44%) maintain an equal monthly shopping frequency, whether online or in-store. This data indicates that individuals from Generation Y shop both online and in physical stores with the same frequency each month.



For 31% of Generation Y respondents, their purchasing frequency is not the same; instead, it is higher online, distinguishing them from Generation X. This data indicates that this group of individuals shops online more frequently than they do in physical stores. In contrast, the remaining 25% display a greater purchasing frequency in physical stores, revealing their preference for in-store shopping over online options.

When considering Generation Z, it becomes evident that the majority of participants (49%) maintain an equal monthly shopping frequency, whether online or in-store. This data suggests that individuals from Generation Z shop online and in physical stores with the same frequency each month.



For 30% of the respondents from Generation Z, their purchasing frequency is not the same, but it is greater in physical stores, similar to Generation X. This data reveals that these individuals shop in physical stores more frequently than online. Conversely, for the remaining 21%, the purchasing frequency is higher online, indicating that these individuals shop online more frequently than in physical stores, also resembling Generation X.

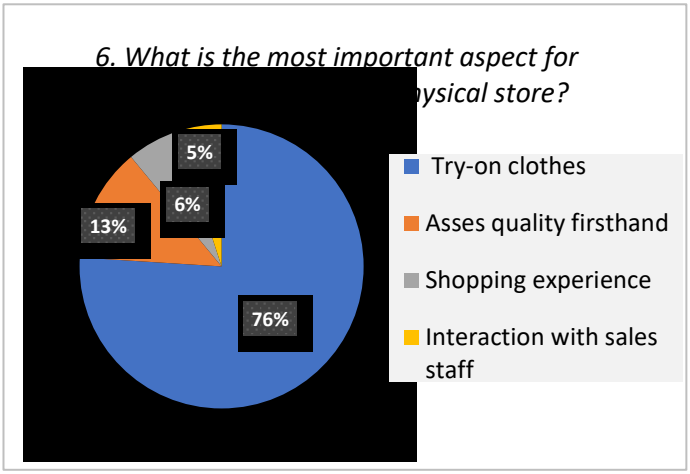
A difference in Generation Y becomes evident when comparing the second majorities, in contrast to Generations X and Z. Indeed, while 29% of Generation Z and 30% of Generation X individuals exhibit a higher monthly purchase frequency in physical stores, for 31% of Generation Y, it is higher online (as opposed to 25% with a higher purchase frequency in physical stores). Below is a table summarizing the data for a more intuitive understanding. Bold text indicates the majorities for each frequency.

	Same frequency	*Greater in store*	*Greater online*
Gen X	**64%**	**29%**	7%
Gen Y	**44%**	25%	**31%**
Gen Z	**49%**	**30%**	21%

In summary, it can be observed that, for the majority of people, irrespective of their generational affiliation, the monthly purchase frequency is the same whether in physical stores or online. This data points to a significant consistency in the purchasing habits of participants in terms of frequency, regardless of the chosen shopping channel.

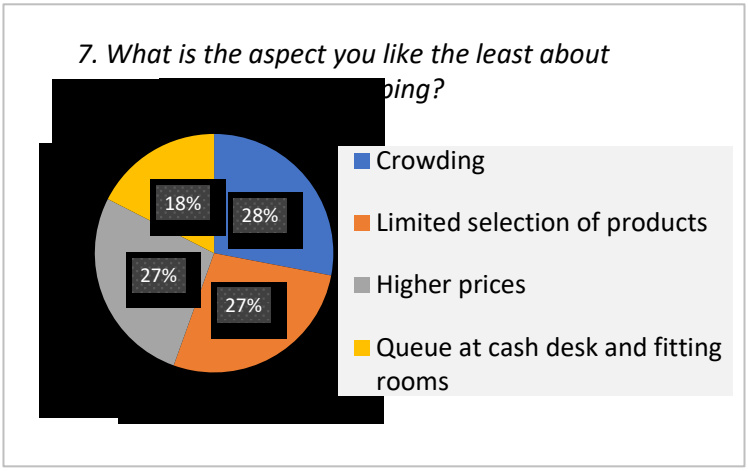
In this case as well, the relationship between the two variables (age and purchase frequency) was not significant (statistical test calculated with SPSS>0.5).

For participants who prefer in-store shopping, the most important aspect when considering online shopping (based on Question 6. *"What is the most important aspect for you when shopping in a physical store?")* is the ability to measure and try on clothes (76%). For 13% of the sample, the most crucial aspect is the opportunity to assess quality firsthand, 6% value the atmosphere and the shopping experience that a physical store provides, while only 5% consider interaction with sales staff to be more important.



It is therefore evident that the ability to try on and measure clothes and accessories before purchasing them is the most important aspect.

On the other hand, the least welcome aspect of in-store shopping (based on question 7. *"What is the aspect you like the least about online shopping?")* turns out to be "crowding" (28%), followed by the "limited selection of products" that the store can offer (27%), "higher prices" in physical stores (27%), and the "queue at the cash desk and in the fitting rooms" (18%).



Question 8. *"Do you prefer to buy clothes, shoes, and accessories in-store or online?"* is particularly intriguing as it aims to explore whether people prefer in-store or online shopping and what factors influence their choice. The question provided three options: "online," "offline" and "depends on" inviting respondents to specify the factors influencing their preference for online or in-store shopping. In addition to the main focus, this question also elicited individual reflections from respondents, which proved to be valuable for the final data evaluation.

The majority of the sample (60%, for a total of 110 people) expressed a preference for in-store shopping, primarily because it allows them to see products in person and because it offers them the possibility of a tactile shopping experience (90%).

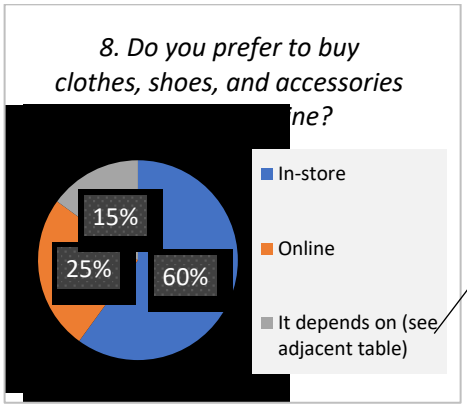
On the other hand, 25% of the sample (corresponding to 48 people) prefer online shopping for the following reasons: online offers and discounts (40%), convenience of shopping from home (37%), and assortment of online products (23%).

15% of the sample did not specify a preference for either online or in-store shopping but specified that their choice depends especially on the *type of products* (x17 people); for example, it emerged that respondents prefer to buy shoes in physical stores much more than clothing, as it is important for them that the shoes fit is perfect and comfortable. Additionally, it was found that when it comes to luxury shopping, people prefer visiting physical stores to have a more luxurious and immersive experience.

Other participants (x6) indicated that their choice between online or in-store shopping depends on the *price*; these people prioritize convenience and opt for the channel where the price is lower, whether online or offline. A few respondents (x3) mentioned that their decision is

influenced by the *urgency* of the purchase. If they need a product immediately, they prefer to visit a physical store to make the purchase promptly, rather than waiting days for shipping.

Data is summarized below.



It depends on:	People
Type of products	x 17
Cheaper price	x 6
Urgency to purchase	x 3

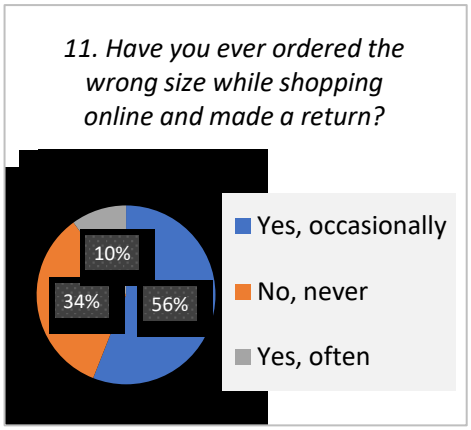
The data thus demonstrate that the majority of the sample (60%) prefers in-store shopping.

Nevertheless, now the aim is to discern the shopping preferences of the three generational cohorts to ascertain whether any disparities exist. It could be surmised that the Generation Z, often recognized as "digital natives," primarily prefer online shopping, whereas the Generation Y and Generation X might be assumed to lean towards in-store shopping, given their characterization as non-digital natives who embraced digital technology in adulthood.

However, an analysis of purchasing preferences across these three generations reveals that a significant majority of Generation X members (78%) exhibit a preference for in-store shopping. Likewise, a majority of Generation Y individuals (53%) prefer in-store purchases. Surprisingly, even among Generation Z, the majority (55%), in contrast to initial expectations, expresses a preference for in-store shopping.

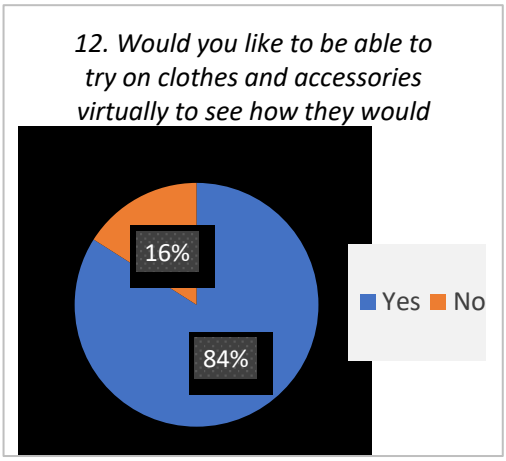
These findings collectively underscore the fact that individuals in the sample, regardless of age, exhibit a substantial inclination toward in-store shopping.

To question *11. "Have you ever ordered the wrong size while shopping online and made a return?"* 56% of respondents answered "Yes, occasionally", 34% answered "No, never", while 10% answered with "Yes, often".



These data show that 66% of the sample experienced more or less occasional problems with ordering the correct size; given the impossibility to try-on products before buying them, a common problem is ordering the wrong size and having to start a return procedure.

To question *12. "Would you like to be able to try on clothes and accessories virtually to see how they would fit you?",* the majority, comprising 84% of the sample, would agree to try products virtually before making a purchase, while 16% would disagree. It might be expected that the 16% primarily consists of individuals from Generation X, who are typically more reluctant to embrace modern technologies and more attached to traditional shopping methods. However, analysing the age of this 16%, it emerges that it composed of young people for more than 90%.



The last question of this section, "*13. What do you think the future holds for online and in-store shopping?"* aims to understand the personal expectations of respondents regarding online and in-store shopping in the near future. The majority (41%) think that in-store shopping will continue to be important for certain product categories, 33% believe that there will be greater integration between online and in-store shopping, 21% believe that online shopping will become the norm, while 6% admit that they do not know what the future of shopping will reserve.

The fact that the majority stated that in-store shopping will continue to be a reference point for certain product categories, shows the enduring significance of physical retail locations for consumers, both now and in the future.

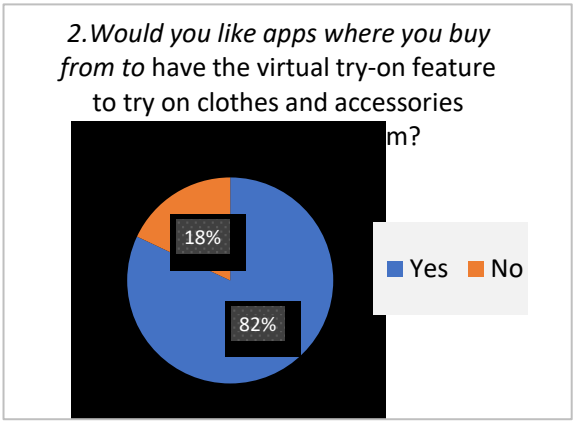
5.2.3 Opinions on AI technologies when shopping

The third section of the questionnaire aims to investigate the opinions and beliefs that respondents have regarding the use of AI technologies, some already widespread, such as visual search, chatbots, and personalized recommendations, while others not yet widespread, such as virtual try-ons, virtual style assistants and smart mirrors, but which will be increasingly common in the future. This section aims to highlight the degree of knowledge of respondents on current AI technologies, their degree of use and possible degree of use for those not yet widespread, as well as the overall evaluation of the shopping experience with the use of artificial intelligence. Understanding the consumers' point of view and their propensity to accept or not these technologies is crucial for retailers considering adopting these AI solutions into their online stores in the future.

To question 1. "*Have you ever heard of virtual try-ons while shopping online?*", the majority, (65%) answered "No", while 35% answered "Yes".

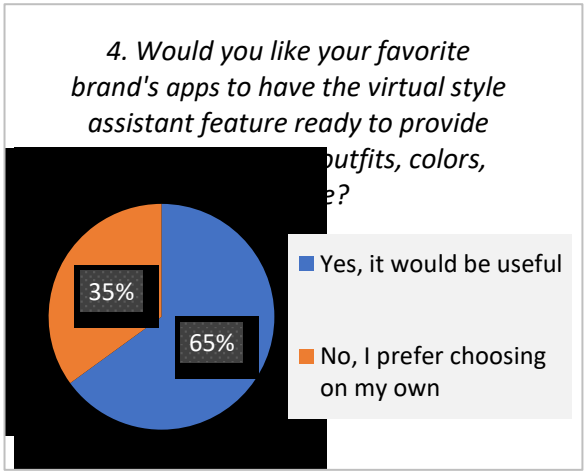
As already mentioned, to enhance clarity, a concise explanation of these technologies was included in the questionnaire since not all respondents were necessarily familiar with their definitions or technical name.

Respondents were then asked (*Question 2.*) if they would like apps, through which they shop online, to have the virtual try-on feature to try on clothes and accessories before making a purchase; a significant majority of 82% answered "Yes", while 18% would not like this feature.

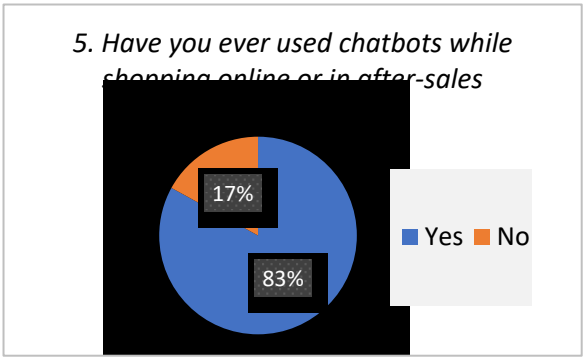


In response to question 3. *"Have you ever heard of virtual style assistants while shopping online?",* 70% of respondents answered "No", while 30% said they had already heard of them.

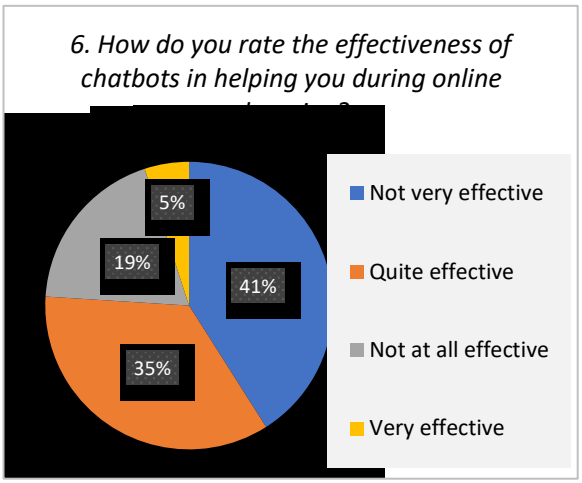
For this technology too, respondents were asked (*Question 4.*) if they would have liked their favourite brands' apps to have the function of virtual style assistant ready to give advice on combinations, colours, and style. It was found that for 65% of the sample, this feature would be very useful, while for the remaining 35% it would not be useful since they would prefer making choice on their own.



Question 5. "*Have you ever used chatbots while shopping online or in after-sales service?*" revealed that 83% of the sample had never used chatbots, while 17% reported having used them at least once.



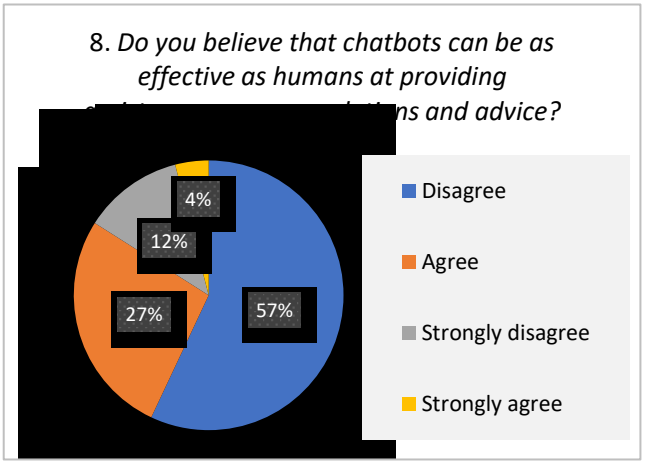
People who answered yes to the previous question (only 17 %), were asked an additional question about chatbots (6. "*How do you rate the effectiveness of chatbots in helping you during shopping online"?).* The data show that the majority of the sample (41%) found chatbots "not very effective", 35% considered them "quite effective", 19% found them "not at all effective", while for only 5% found them "very effective".



Analysing these data, it is possible to deduce that the effectiveness of chatbots for most respondents is rather negative.

Instead, respondents who have never used chatbots (83%) were asked question 7. *"Would you trust a chatbot to give you online assistance, advice, and recommendations?"* and data revealed an even split, with 50% indicating they would trust a chatbot, while the remaining 50% would not.

Question 8. *"Do you believe that chatbots can be as effective as humans at providing assistance, recommendations and advice?"* aims to understand respondents' opinion about the effectiveness of chatbots compared to humans. The majority (57%) disagree, 27% agree, 12% strongly disagree, while only 4% strongly agree with the question. Reading this data, it is possible to understand that, according to the majority of the respondents, chatbots cannot be absolutely as effective as humans in their functions. Let us try to understand why by analysing the short open-ended answers provided by 91 out of 190 respondents, as the question was optional (Question 9. *Justify your answer*).



Answers are summarized and grouped in the table below.

9.Justify your answer	*People*
Absence of empathy, emotions or sensitivity	x15
Incapacity for providing opinions, judgments, and personalized advice	x16
The absence of a human element in customer service	x10
The impossibility of achieving a human-like experience	x9
Use of standard and stereotypical responses, risk of uniformity	x9
Limited comprehension	x7
Incapacity to solve complex problems	x4
A lack of creativity, taste, and imagination	x4
A lack of trust	x4
AI is not yet fully developed in this field	x3
Inability to always work properly	x1
TOT.	**82**

As evident from the answers, fifteen people (x15) declared that chatbots do not possess qualities such as empathy, the ability to feel emotions and sensitivity, fundamental characteristics for customer support and to be able to provide personalized style recommendations tailored to each customer's unique and individual characteristics. The interviewees also specify that empathy is an exclusively human characteristic, therefore impossible to achieve by artificial intelligence.

Sixteen people (x16) state that chatbots cannot be as effective as humans in providing assistance and style advice due to their inability to express opinions, make personal judgments and consequently offer personalized advice. When it comes to receiving advice on style, colours, and combinations, it emerges that people prefer advice and opinions from sales associates, or in any case, real people, capable of suggesting the best combinations based on each customer's physical attributes, age, and preferences.

Ten people (x10) instead, mentioned the "absence of a human element" in chatbots.

Nine people (x9) pointed out that the human experience is more effective and according to them, it cannot be achieved with AI. Also in this case, it emerges that the human element is closely linked to qualities like empathy and flexibility, which chatbots often lack, resulting in mechanical responses.

In fact, another nine people (x9) stated that chatbots cannot be as effective as humans, especially in providing personalized style recommendations, due to their automatic, standardized, and stereotypical responses which could lead to the risk of uniformity. According to these respondents, fashion advice should be tailored to each individual, after considering factors like body type, hair colour, age, and personal preferences. Chatbots, incapable of capturing all these nuances, risk providing generic advice to people seeking uniqueness.

Seven people (x7) instead mentioned the "limited comprehension" of chatbots, specifying that current technology is not as much developed to create chatbots with text comprehension at a human level. Currently AI-based chatbots are only able to solve simple problems, so when it comes to handling particular requests and problems, the chatbot is not enough, and the intervention of a human assistant able to solve the problem is necessary. The lack of comprehension is strongly associated with the "incapacity to solve complex problems", mentioned by four people (x4).

Other people cited the "lack of creativity, taste and imagination" in chatbots (x4), others mentioned a "lack of trust" in chatbots (x4). A few respondents expressed the view that “AI is

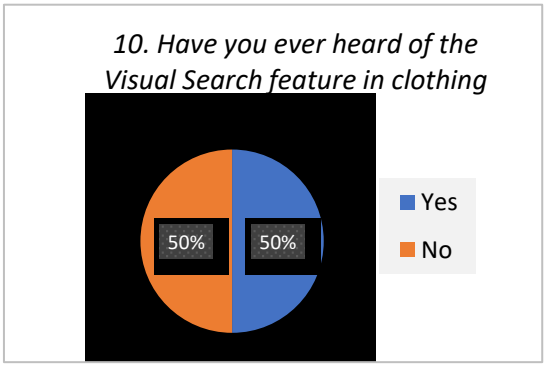
not yet fully developed in this field" (x3) and one respondent mentioned their "inability to always work properly" (x1).

Among the 91 respondents, only 9 had positive views about chatbots. According to these individuals, chatbots can be even more effective than humans in providing assistance and advice because they can utilize a wealth of customer data, including past purchases, items in the cart, and search history. However, two respondents expressed concerns that chatbots could also be programmed to influence or manipulate the sale of certain products.

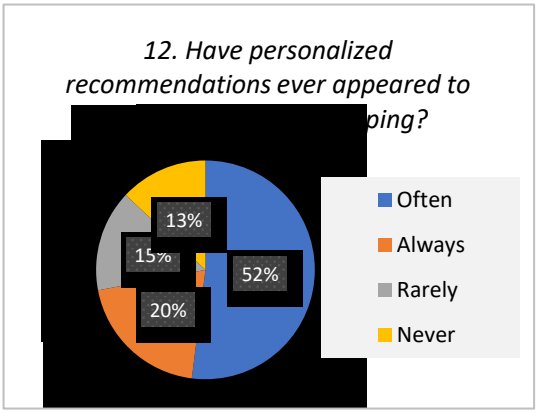
9.Justify your answer	*People*
Chatbots can do a great job	x2
Chatbots are very helpful	x2
Chatbots provide precise personalized recommendations	x2
Chatbots have the potential for effective colour matching	x1
Chatbots can process info better than humans	x1
Chatbots can solve problems faster than humans	x1

In summary, the majority of participants hold a negative perception of chatbots. People look for empathy and sensitivity, both in customer service and personalized style advice. Another big problem with chatbots is that they offer standard and automatic responses, therefore lacking creativity; in the context of fashion, this could pose a problem, potentially contributing to a sense of conformity in fashion choices.

To question 10. *"Have you ever heard of the Visual Search feature in clothing apps?"*, 50% answered "No", while 50% answered "Yes" indicating that they had used it at least once. Visual search is already a fairly common function in fashion retail (and retail in general), and the fact that half of the sample has used it is proof of its widespread adoption.



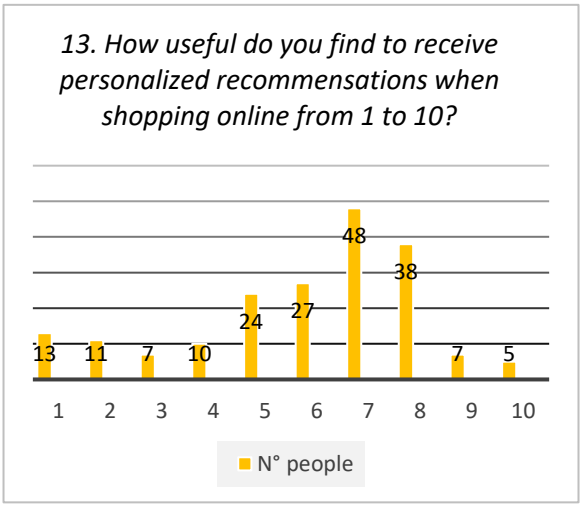
Question 12. *"Have personalized recommendations ever appeared to you during online shopping?"* aims to explore how often personalized recommendations appear to respondents. Analysing the data, it is possible to understand that for the majority of respondents (52%), they appear *often*, for 20% they appear *always*, for 15% they appear *rarely,* while for 13% they *never* appear.



Personalized recommendations are solutions based on artificial intelligence widely used by retailers in the promotion of fashion products; in fact, approximately 70% of the sample indicates noticing them with a high frequency (*often/always*).

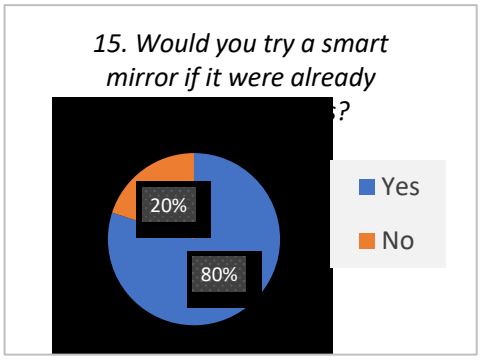
Receiving personalized recommendations can be highly beneficial as it helps customers discover products that match their interests, saving them time in the search process. Additionally, it can introduce customers to new styles, brands, or trends they may not have initially considered, contributing to the diversification of their wardrobe.

To gauge the utility of personalized recommendations for respondents, question 13 was asked *"How useful do you find to receive personalized recommendations when shopping online from 1 to 10?"*. The data revealed that the majority of participants consider personalized recommendations useful, with an average score of 7 on the 1 to 10 scale, where 1 represents "not very useful" and 10 represents "very useful".

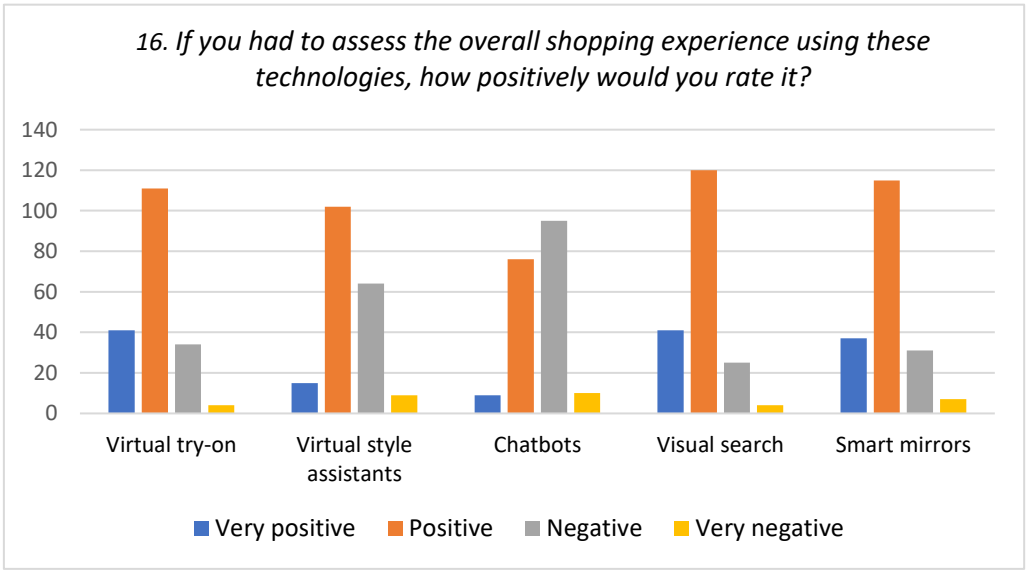


To question 14. *"Have you ever heard of smart mirrors?"* 78% answered "No", while 22% indicated they had already heard of them.

Smart mirrors are still in development and not yet widely widespread. However, given their potential as mirrors of the future in fashion stores, respondents were asked Question 15. *"Would you try a smart mirror if it were already available in stores?"*. Data shows that 80% would like to try it, while 20% are not interested.



The last question in this section (Question 16. "*If you had to assess the overall shopping experience using these technologies, how positively would you rate it?"*) aims to assess participants' overall perception of the shopping experience with the implementation of these technologies. The data indicates that integrating all these AI technologies (including those not yet available or widespread) into the shopping experience would receive a *positive* evaluation from the majority of participants, except for chatbots which received a negative overall evaluation (as it can be seen from the chart below).



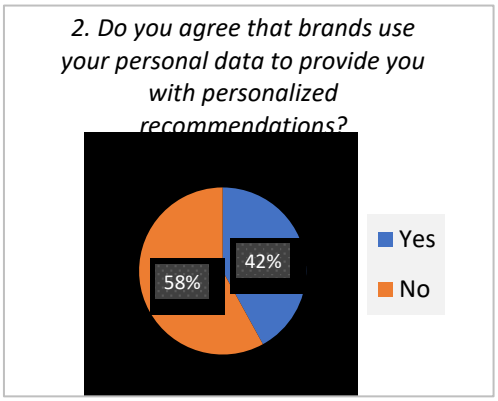
5.2.4 Degree of concern about the use of these technologies

As discussed in chapter two of this thesis, the adoption of AI technologies by companies raises concerns among consumers regarding their privacy and the security of their personal data. In fact, companies use AI systems to collect and analyse a large amounts of customer data with the aim of enhancing the shopping experience. However, the acquisition and processing of personal data raises serious concerns about how this data is used, shared, and about the potential

risk of unauthorized access by third-party companies that are not transparent in their privacy policies.

This last section of the questionnaire aims to assess participants' level of concern when it comes to sharing their personal information while online shopping.

In response to question 1. *"Are you aware that brands are using your personal data to provide you with personalized recommendations, emails, and ads tailored to your needs?"* 95% answered "Yes", while 5% were unaware of it.



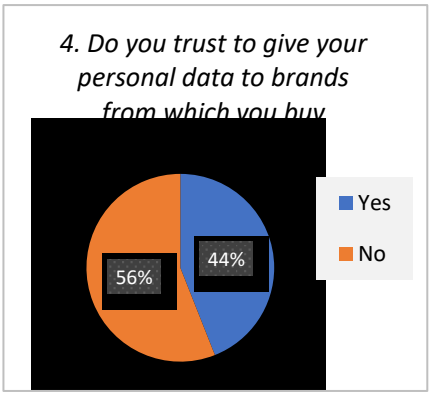
To question 2. *"Do you agree that brands use your personal data (email, phone number, purchase history) to provide you with personalized recommendations?"*, 58% of the sample disagreed, while 42% agreed. It might be assumed that individuals from Generation Z, who have grown up as digital natives, are considerably more likely to agree with the idea that brands use personal data to offer recommendations, compared to individuals from Generation Y and X. Indeed, the data reveal a significant relation between age and agreement with the question (statistical test calculated with SPSS showing a significance level of 0.011. This data indicates that younger individuals are much more in agreement compared to older individuals.

It is worth mentioning that there are missing values in this question (in fact, only 182 out of 190 people responded to question 2). This means that the results of test might not be valid. Additionally, it's important to remember that the sample is not homogeneous in terms of age (with 77% of individuals from Generation Z), which could further influence the significance level.

Question 3. "*How much worried are you about sharing your personal information while shopping online to get personalized recommendations?"* requires indicating the level of concern of respondents about sharing their personal information while shopping online; The data shows that 44% are "Fairly concerned", 39% are "slightly concerned", 11% are "very concerned", while 6% are "not

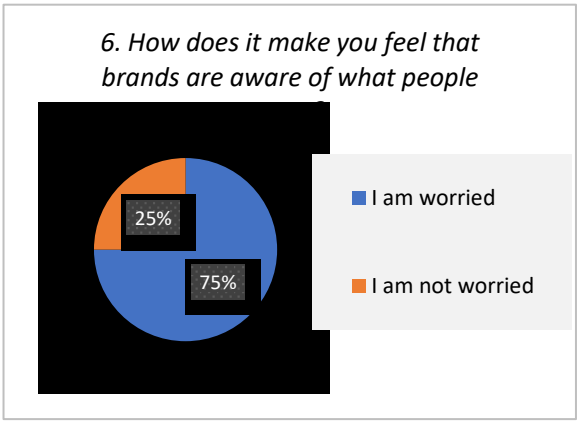
concerned at all". So, it can be said that the majority (55%) of the sample is concerned about their privacy.

Based on question 4. "*Do you trust to give your personal data to brands from which you buy regularly?"* it emerges that the majority, comprising 56%, do not trust, while 44% exhibit trust. The fact that almost 60% of the sample lacks confidence in sharing their data with their favourite brands is not a good sign for the companies in question, which should enhance the clarity and transparency of their privacy and security policies to instil a sense of safety and protection among consumers.

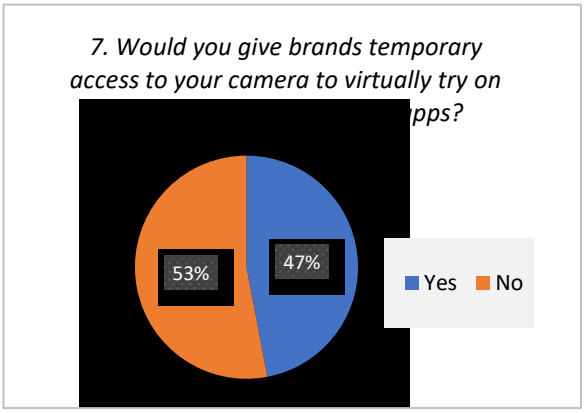


To question 5. ("*Have you ever searched for a product online and then seen similar ads on other platforms?")*, the majority of respondents (76%) stated that they *often* receive similar ads on other platforms when searching for a product online. So, participants were then asked Question 6. *"How does it make you feel that brands are aware of what people want?".*

The majority (47%) admit having some *worries and feeling controlled*, 25% are *quiet and with no worries*, 20% have *many concerns* about their privacy, while 8% have *many concerns and would like not to receive them anymore*. In summary, it can be concluded that 75% of the sample has more or less strong concerns, while only 25% is totally calm.



Participants were then asked if they would give the apps where they regularly buy from, temporary access to their camera to virtually try on clothes and accessories (Question 7. *"Would you give brands temporary access to your camera to virtually try on clothes and accessories on apps?").* The data shows that 53% disagree, while 47% agree.



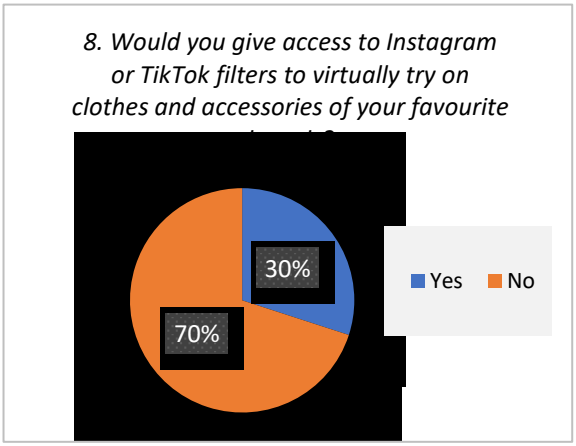
These results indicate that most people are still hesitant and lack confidence when it comes to sharing their camera access for virtual clothing try-ons, even with brands they regularly buy

from and should trust. If the future of fashion retail involves the adoption of virtual try-ons, a feature considered very useful and interesting by consumers, it is important for retailers to implement and share clear and transparent privacy policies with their customers. This will enable customers to feel safe and protected, ultimately making them more willing to embrace these tools in the near future.

For this question as well, it was deemed interesting to compare individual responses with the age of each participant to ascertain whether young individuals from Generation Z, in comparison to individuals from Generation Y and X, were more inclined to grant brands temporary access to their camera to virtually try on clothing and accessories. Indeed, the data reveal a significant relationship between age and the propensity to respond affirmatively to the question (test in SPSS showing a significance level of 0.04). This result confirms that younger individuals are much more in agreement compared to older individuals.

It's worth noting that there are missing values in this question (in fact, only 182 out of 190 people responded to question 7). This implies that the outcomes of the test may lack validity. Furthermore, it's crucial to bear in mind that the age distribution within the sample is not consistent (with 77% of participants belonging to Generation Z), which could potentially have an additional impact on the test's significance level.

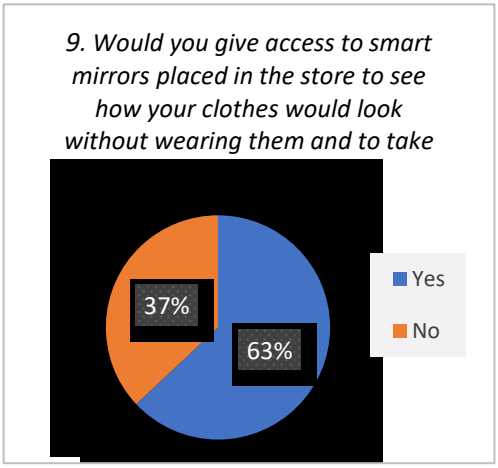
Question 8. *"Would you give access to Instagram or TikTok filters to virtually try on clothes and accessories of your favourite brands?",* is very similar to question 7, but in this case, participants were asked if they would give access to platforms such as Instagram and TikTok, for trying on clothes and accessories using filters. The data shows that 70% would disagree, while 30% would agree.



Compared to Question 7, it becomes evident that people are more inclined to grant camera access for virtual clothing try-ons through official brand apps rather than through social media platforms. Two assumptions can help explain this data. First, Instagram and TikTok are primarily social platforms where the use of filters is often associated with fun and playfulness rather than practical purposes like online clothing selection. Second, trust plays a significant role: even though Instagram and TikTok require camera access, just like brand apps do for the 'virtual try-

on' function, users may find it more acceptable and have fewer concerns about data misuse when it occurs within the official app of a trusted brand.

It might be expected that younger people who typically use more social media platforms, such as Instagram and TikTok, should be more inclined to give access to Instagram and TikTok filters to use the virtual try-on feature. To the validity of this hypothesis, the association test was employed, revealing a significance level of less than 0.01, thus confirming the hypothesis. Also in this case, it is worth noting that there are some missing values in this question (Question 8) as only 182 out of 190 people answered, and the empty cells might have affected the results of the test. Additionally, it's important to remember that the sample is age-biased (with 77% of individuals from Generation Z), which could further influence the significance level of the test.



To question 9. *"Would you give access to smart mirrors placed in the store to see how your clothes would look without wearing them and to take pictures?",* 63% answered "Yes", while 37% answered "No". Participants are significantly more willing to grant access to their personal image to smart mirrors in physical stores compared to allowing access to their cameras for virtual try-on functions. This difference in behaviour can be attributed to privacy concerns. Consumers may feel more secure sharing their image with a smart mirror in a physical store since it does not involve sharing additional sensitive information stored on their phones, beyond their real-time image.

The last question, question 11. *"How worried are you from 1 to 10 that third parties may breach your personal, payment, and photo data?"* is designed to assess respondents' level of concern regarding the security of their sensitive data. On average, the sample exhibits a relatively high level of concern, with an average score of 7.5.

5.3 Conclusions

It is clear that artificial intelligence is no longer science fiction, but a reality that will become increasingly prevalent in the next years. Artificial intelligence has made significant progress in various sectors, such as information technology, healthcare, finance, education, and retail. In reality, in the fashion retail sector in particular, AI is not yet widely used, but given the rapidly advancing technological progress, it is highly likely to become so in the near future.

Currently, common applications of AI in fashion retail encompass personalized recommendations, visual search capabilities, and chatbots. On the other hand, emerging technologies in experimental stage include virtual try-on experiences, smart mirrors, and virtual style assistants. Nevertheless, research and analysis indicate that, as technological progress continues, these experimental technologies will be ready for widespread adoption in the coming years.

Considering the future and not-so-distant transformation of the customer shopping experience through the implementation of these technologies, it is compelling to delve into consumer sentiments and apprehensions regarding their utilization. Gaining insights into consumer perceptions, levels of trust, and concerns is pivotal for anticipating how consumers will coexist with AI in the realm of fashion retail and for identifying the primary obstacles retailers must navigate to integrate these technologies into their apps.

Despite the non-representative nature of the sample used for the empirical research, it has yielded valuable and interesting insights. Below, a summary of the empirical research results is provided.

In the second section of the questionnaire, which is dedicated to investigating the habits and purchasing preferences of the respondents, it stands out that nearly the entire sample (92%) reported having shopped online at least once. This data confirms the popularity of e-commerce, which, as mentioned in Chapter three, has grown disproportionately with the spread of the Covid-19 pandemic. In this sense, the pandemic played a crucial role in the fashion sector, accelerating the growth of e-commerce.

The remaining 8%, on the other hand, stated that they have never shopped online. It might be expected that this 8% primarily consists of individuals from the Generation X, older individuals who are not considered "digital natives" and are thus hesitant to online shopping. However, the data contradicts this hypothesis, showing that 85% of the Generation X respondents

have shopped online at least once. Therefore, online shopping is not exclusive to younger age groups, but extends to older age groups as well.

Regarding the shopping habits in terms of monthly frequency, it emerges that participants shop *rarely*, meaning less than once a month, whether it is through online channels or in physical stores.

Subsequently, individual responses from the participants regarding the frequency of online and in-store purchases were analysed to determine if it is the same or different in the two shopping modes. The data reveal that for the majority of the sample (51%), regardless of age, the purchase frequency is the same. This data indicates that most people shop online and in physical stores with the same frequency: for instance, a person who *occasionally* (once or twice a month) shops online will also do so in physical stores with the same frequency.

For the majority of the interviewees, the most important aspect during online shopping is the convenience of competitive prices. Indeed, online shopping is generally more cost-effective compared to in-store purchases, owing to several factors. Firstly, there are many more competing sellers online compared to physical stores in a specific geographical area. This competition often leads to more competitive prices, providing buyers with the ability to easily compare prices and choose the most advantageous one for them. Secondly, e-commerce businesses have lower operational costs compared to physical stores, as they don't have to bear expenses such as renting physical space or costs associated with a large sales staff. This can result in lower prices for consumers.

On the other hand, the least favoured aspect of online shopping for most respondents is the inability to physically try on clothes and accessories. Indeed, without the ability to physically try on clothing, it becomes more challenging to assess fit and size. Even knowing the size, the actual dimensions of a garment can vary between different manufacturers or brands, leading to disappointments if a garment doesn't fit properly when it is delivered.

From the questionnaire analysis, it is evident that over half of the respondents (66%) have experienced issues with ordering the correct size, having to start a return process. They have also pointed out that, although it is possible to return and exchange items purchased online, the return process can be inconvenient (printing return labels, visiting the post office, waiting for refunds).

The inability to try on items is indeed one of the primary limitations of online shopping, but it could potentially be overcome in the future with the implementation of effective virtual try-on solutions that allow customers to virtually try on products using their phone's camera.

Moving on to in-store shopping, for the majority of the respondents, the most important aspect is the ability to measure and try on clothes, followed by the ability to physically assess fabric and quality. On the other hand, the less favoured aspects during in store-shopping are almost equally divided between overcrowding, the limited product selection that a store can offer, and higher prices.

Regarding the preference for online or in-store shopping (*Question 8. Do you prefer to buy clothes, shoes, and accessories in-store or online?*), the majority of the sample (60%) states a preference for in-store shopping precisely because it provides a tactile shopping experience that allows them to see the products in person, try them on, and assess their quality. Meanwhile, 25% prefer online shopping because it offers greater online promotions and discounts compared to physical stores, as well as the convenience of shopping from home, and a wide range of products. The remaining 15% do not have a fixed preference, and their choice to shop online or in-store depends on factors such as the type of products they want to buy, the most cost-effective option, and the urgency of the purchase.

In summary, it is evident that the majority of the interviewees prefer in-store shopping and believe that physical retail locations are, and will continue to be, essential reference points for certain product categories, such as shoes and luxury items.

The third section of the questionnaire is dedicated to investigating the respondents' knowledge of current technologies and their potential overall assessment of the shopping experience with the use of AI-powered solutions.

The majority of the interviewees (65%) were not aware of the virtual try-on technology; however, they would appreciate that their favourite fashion apps had this function to try on clothes and accessories before purchasing them. Therefore, the perception of the potential use of this technology in fashion retail appears to be positive for most participants.

Similarly, when it comes to the virtual style assistant technology, the majority of the interviewees (70%) were not aware of it, but they would appreciate that the apps they use for shopping had this function to provide advice on outfit combinations, colours, and style. Concerning the potential use of this technology in the future, most participants have a positive perception.

Regarding chatbots, which are already widely used in retail, the majority of the interviewees (83%) claim not to have used them. They were then asked if they would trust a chatbot to provide assistance and advice, and it emerged that 50% would trust it, while the other 50% would not.

Of the 17% who had used chatbots at least once, they rated them as not very effective. From this data, it can be inferred that chatbots are perceived as relatively ineffective by the interviewees.

Subsequently, the respondents were asked whether they believed chatbots could be as effective as humans in providing assistance and advice (Question 8). In this case as well, the majority of the sample appears to disagree, highlighting that chatbots will never be able to match human assistance, especially for the following reasons: lack of empathy, emotions, and sensitivity; inability to provide opinions, judgments, and personalized advice; absence of the human element in customer service; limited comprehension; use of standardized and stereotypical responses that lead to the risk of homogeneity; inability to solve complex problems; and a lack of creativity, taste, and imagination.

Actually, chatbots can be awkward and mechanical, and often have a limited set of answers that not always satisfy the customer's needs. In fact, the empirical analysis showed that only 3,7% of respondents strongly believe that chatbots can be as effective as humans to give assistance and advice when shopping for clothes and accessories. This low percentage highlights that most of the participants still question robot's abilities to provide them the assistance they need.

However, there is good news for chatbots: although today's chatbots are typically rule-based, relying on predefined responses, Generative AI[109], such as GPT[110] (Generative Pre-trained Transformer), is poised to revolutionize the world of chatbots in the next years. These advanced AI models understand context, decipher human language intricacies, and generate responses that are coherent, contextually relevant, and strikingly human-like.

This enhancement is highly likely to transform consumers' perceptions of chatbots from negative to positive and if that's the case, both chatbots and virtual style assistants will enjoy tremendous success.

Regarding the visual search technology, which is already quite widespread in clothing apps, it appears that 50% of the respondents have heard of it and admitted using it at least once, while the other 50% were not aware of this function.

[109] Generative AI is a subcategory of artificial intelligence (AI) that focuses on creating AI models capable of autonomously generating data, content, or responses. These models employ machine learning techniques, particularly artificial neural networks, to produce data or content that is similar to what is generated by humans.

[110] A well-known example of generative AI is the GPT (Generative Pre-trained Transformer) model developed by OpenAI, which can generate text that is humanly coherent and contextually relevant across a wide range of topics.

Regarding personalized recommendations, which are also widely used by retailers, participants were asked how often they appear to them during online shopping. The majority of the interviewees (70%) claim to see them frequently (always or often).

Receiving personalized recommendations can be extremely useful for customers as it allows them to save time in their search and discover interesting products they may not have initially considered. For the interviewees, receiving personalized recommendations is deemed useful with an average rating of 7 on a scale from 1 to 10, where 1 is "not very useful" and 10 is "very useful."

Regarding the last technology considered, which is smart mirrors, it appears that the majority (78%) were not aware of them but would be willing to try them if they were available in stores. As for the potential use of this technology in the future, most participants have a positive perception since the majority is curious to try it.

In summary, it can be stated that the integration of all these AI technologies (including those not yet available or widespread) into the shopping experience would receive a positive evaluation from the majority of the participants, except for chatbots, which received the highest negative rating.

The fourth and final section of the questionnaire aims to investigate the level of concern among participants regarding sharing their personal information during online shopping. As mentioned earlier, companies use artificial intelligence-based systems to collect and analyse a large amount of customer data with the goal of enhancing their shopping experience and providing personalized recommendations. However, the collection of personal data raises concerns about unauthorized use by third-party companies.

The majority of the interviewees (95%) are aware that companies use their personal data to provide personalized recommendations, emails, and advertisements tailored to their needs. However, when asked whether they agree that companies use their personal data to provide a better shopping experience, the majority (58%) disagrees. This data suggests that most interviewed individuals are concerned about privacy and may perceive the use of personal data as invasive or unwanted.

Companies should take into consideration feedback from their customers and strive to balance the use of personal data with consumer privacy. They could also work on transparently communicating how they use data and providing users with options to control their data. This can help improve consumer trust and reduce dissatisfaction with companies' data usage practices.

Furthermore, data show that the majority of people (56%) do not have confidence in sharing their personal information even with their favourite fashion brands or brands from which they regularly make purchases. This data is a negative signal for these companies, indicating that they should work to make their privacy and security policies clearer and more transparent to ensure that consumers feel safe and protected. Building trust with consumers in terms of data privacy is crucial in today's digital age.

Nowadays, when people search for a product online on one platform, there is a high probability that related ads will also appear on other platforms used by those individuals; this phenomenon is referred to as "online tracking." Online tracking is a process that involves the collection of people's data related to their web browsing, interactions with websites, apps, and advertisements. It is used by many companies for various purposes, including content personalization and targeted advertising. Actually, when the interviewees were asked if they had ever experienced searching for a particular product online and then seeing similar ads on other platforms, the majority (76%) responded "Yes." Moreover, the 75% of them express concerns about their privacy and feeling monitored, while only 25% feel at ease.

This highlights that a massive portion of individuals is uneasy about online tracking and its implications for their privacy.

Subsequently, respondents were asked if they would grant shopping apps temporary access to their camera to try on clothes and accessories virtually, and the data reveals that the majority (53%) disagree. This data contrasts with the findings from question 2 in the second section (2. *"Would you like the apps you use for online shopping to have the virtual try-on feature for trying on clothes and accessories before buying?"*), which shown that the majority (82%) would like apps to have the virtual try-on feature.

These findings data suggest that that the benefits of such features might not be enough to convince users of sharing their personal information, such as their camera ‘access.

In summary, it can be stated that people would appreciate the virtual try-on feature; however, they are concerned about their privacy and how access to their camera is managed by apps that provide this feature. Therefore, it is important that, when this feature becomes widely available, companies communicate transparently with customers about how they use data and provide users with options to control their data. Only in this way can people enjoy this very useful feature without worries.

When respondents were asked if they would grant access to smart mirrors placed in stores to see how clothes would look on them without wearing them and to take photos, the majority (63%) answered "Yes." This positive response from the majority of the sample is surprising because it highlights a strong level of trust on the part of the interviewees towards this technology, unlike the virtual try-on feature.

This finding indicates that participants are much more inclined to grant access to their personal image to smart mirrors in stores, than to give access to their camera for the virtual try-on feature. In this case, the assumption that can be made to explain this result is related to privacy: consumers feel more secure sharing their image with a smart mirror placed in a store because, unlike the virtual try-on feature, it does not require sharing other sensitive information contained in consumers' phones, beyond their real-time image.

The last question of the questionnaire was asked to investigate the average level of concern among the interviewees regarding the violation of their sensitive data. The data reveals that the sample has a fairly high level of concern with an average rating of 7.5 on a scale from 1 to 10. This indicates that the interviewees have significant concerns about the security and privacy of their sensitive data.

Overall, the survey generated interesting findings, providing valuable insights into the attitudes of the respondents towards AI technologies in the fashion retail industry. Above all, it is evident that privacy concerns are prevalent among consumers. This indicates that a significant portion of individuals has worries about how their personal information is managed and these worries could potentially lead to hesitancy from retailers in adopting these technologies in the future.

Artificial intelligence is a powerful tool with the potential to transform the fashion retail industry and significantly improve the consumer shopping experience. Nevertheless, there are two main challenges that AI must address: consumer biases and concerns towards these tools, and the ongoing issue of technology not yet developed to make these AI-based tools work at their best.

Concerning the first issue (and as observed in the field research), there is still a level of resistance from customers to use artificial intelligence solutions for apparel retail; this might be caused by multiple reasons, such as privacy concerns or the lack of awareness and exposure to such tools. To ensure that consumers are not apprehensive and have confidence in these AI solutions, it is fundamental for companies to adopt and share transparent policies regarding the

use of personal data with their customers. This will contribute to making consumers feel entirely secure and well-protected, ready to enjoy a completely new and engaging way to live the shopping experience, both online and in-store.

Concerning the second issue related to the quality of these AI-based tools, let's think about chatbots, virtual try-on and smart mirrors.

As already mentioned, chatbots are not as efficient as humans yet, although they may become so in the future if powered by generative AI. Other examples can be the virtual try-on feature and smart mirrors. The possibility to try clothes and accessories virtually, eliminating the necessity of physical presence, can be a revolutionary tool. This is valuable not just for online shopping but also for brick-and-mortar stores with limited inventory or those aiming to enhance the customer engagement experience.

However, the current status of virtual try-on technology falls below the desired standard, featuring low-resolution images and resulting in unnatural clothing material movements when using the feature via the phone's camera.

Just like chatbots, it is yet hard to imagine virtual try-on being on equal grounds with trying on clothes and feeling their textures, fabrics and fitting. However, some companies are investing to improve the augmented reality tool, and it is likely that in the future this feature will not exist only in an experimental stage, but it will be easily accessible to a wide audience.

If technological development advances to the point where AI-powered solutions transition from being just an additional feature or primarily used for marketing and engagement (e.g., smart mirrors) to becoming valuable tools that assist online shoppers or even serve as partners in addressing health crises (like the COVID-19 pandemic) by reducing human contact, there is room for AI-powered solutions to become more prevalent and significant in the apparel retail sector.

Due to increasingly rapid technological advancements, there is a strong probability that these AI technologies will attain a high level of quality and performance, resulting in their widespread adoption throughout the fashion retail sector. Nevertheless, for this adoption to be successful and to provide a return on the investments made to develop these AI-powered solutions, it is essential that consumers are prepared to embrace them without harbouring concerns or biases, even if this is a lengthy and intricate process.

Discussions around tech show two faces of the same coin: on the one hand, technology has become an integral part of our daily lives, and we increasingly depend on it to function

effectively, solve problems, and even navigate crises. It has proven invaluable in times of need, including emergencies and global challenges like the COVID-19 pandemic. Nowadays people rely on technology for communication, remote work, education, healthcare, banking, shopping and much more.

On the other hand, this growing reliance on technology has also given rise to concerns and fears. As technology evolves and becomes more integrated into our lives, there is a legitimate apprehension about its negative impacts. These concerns include especially issues related to privacy and data security, but also to the potential loss of jobs to automation.

The once optimistic view of technology as positive force for society is now tempered by a sense of suspicion and distrust. People are increasingly aware of the potential downsides and unintended consequences of technology, leading to a more critical and cautious approach to its adoption and use. In the digital age, striking a balance between reaping the benefits of technology and addressing these concerns is a significant challenge.

However, the impact of artificial intelligence in the fashion industry in the near future appears promising, driven by the potential technological advancements that stand to benefit both companies and customers. But, it is important that consumers are willing to accept these technologies and that companies maintain transparency in their use of customer personal data. These two essential elements, which are closely related, are the key to ensure the harmonious coexistence of artificial intelligence, fashion, and customers in the near future.

Annexe 1 - Questionnaire

Intelligenza artificiale nello shopping e percezione del consumatore

Sezione 1- Dati anagrafici

1.Genere

-Maschio

-Femmina

-Non-binario

-Preferisco non specificare

2.Età

_____

3.Regione di nascita

_____

4. Titolo di studio

-Elementari

-Medie

-Superiori

-Laurea triennale

-Laurea magistrale

-Altro (specificare)

5.Occupazione

- Studente/studentessa

- Occupato/a

-Disoccupato/a

Sezione 2 - Opinioni sullo shopping online e in negozio

1. Hai mai comprato vestiti, scarpe o accessori online? (se NO, vai alla domanda 5)

-Si

-No

2. Quanto spesso compri vestiti/accessori online in media in un mese?

-Molto spesso (più di una volta a settimana)

-Spesso (una volta a settimana)

-Occasionalmente (una/due volte al mese)

-Raramente (meno di una volta al mese)

3. Quale ritieni essere l'aspetto più importante durante lo shopping online?

-Comodità di fare acquisti ovunque

-Convenienza, prezzi competitivi

-Ampia selezione di prodotti

-Possibilità di avere il rimborso se l'acquisto non è soddisfacente

-Altro (specificare)

4. Qual è l'aspetto che meno ti piace dello shopping online?

-Non poter provare e misurare fisicamente capi e accessori

-Non poter testare con mano tessuto e qualità

-Pratiche di reso e rimborso (stampare etichetta reso, recarsi in posta, attendere il rimborso)

-Tempi di consegna

-Altro (specificare)

5.Quanto spesso compri vestiti/accessori in negozio in media in un mese?

-Molto spesso (più di una volta a settimana)

-Spesso (una volta a settimana)

-Occasionalmente (una/due volte al mese)

-Raramente (meno di una volta al mese)

-Mai (non faccio mai shopping in un negozio)

6. Quale ritieni essere l'aspetto più importante durante lo shopping in negozio?

-Possibilità di misurare e provare vestiti

-Possibilità di testare la qualità

-Interazione con il personale di vendita

-Atmosfera ed esperienza di acquisto (colori, profumi, vetrine...)

-Altro (specificare)

7.Qual è l'aspetto che meno ti piace dello shopping in negozio?

-Fila in cassa e nei camerini

-Prezzi più elevati

-Limitata selezione dei prodotti

-Affollamento

8. Preferisci acquistare vestiti, scarpe e accessori in negozio o online?

-In negozio

-Online

-Dipende da: specificare

9. Se hai scelto in negozio, perché?

-Esperienza di shopping tattile

-Consulenza da parte del personale di vendita

-Possibilità di vedere i prodotti di persona

-Preferisco l'interazione con altri clienti/persone del negozio

10. Se hai scelto online, perché?

-Offerta e sconti online

-Assortimento di prodotti online

-Comodità di fare acquisti da casa

-Consigli di amici o recensioni online

11. Ti è mai capitato di ordinare la taglia sbagliata durante lo shopping online e fare il reso?

-Si, spesso

-Si, occasionalmente

-No, mai

13.Ti piacerebbe poter provare vestiti e accessori virtualmente per vedere come ti starebbero addosso?

-Si

-No

14. Cosa pensi che il futuro riservi allo shopping online e in negozio?

-Lo shopping online diventerà la norma

-Lo shopping in negozio continuerà a essere importante per alcune categorie di prodotti

-Vedremo una maggiore integrazione tra shopping online e in negozio

-Non so, è difficile prevedere il futuro dello shopping

Sezione 3 - Opinioni sulle tecnologie AI durante lo shopping

1. Hai mai sentito parlare dei virtual try-on durante lo shopping online? (il virtual try-on consente agli utenti di provare virtualmente vestiti, accessori o trucco utilizzando la fotocamera del telefono)

-Si

-No

2. Ti piacerebbe che le app attraverso cui fai shopping online abbiano la funzione di virtual try-on per provare vestiti e accessori prima di acquistarli?

-Si

-No

3. Hai mai sentito parlare di assistenti di stile virtuali durante lo shopping online? (gli assistenti virtuali sono bot, cioè software che ti danno consigli di stile)

-Si

-No

4.Ti piacerebbe che le app dei tuoi brand preferiti abbiano la funzione di assistente di stile virtuale pronto a darti consigli su abbinamenti, colori e stile?

-Si, sarebbe utile

-No, preferisco scegliere da solo/a

5. Hai mai utilizzato i chatbots durante lo shopping online o nel servizio post-vendita? (I chatbot sono applicazioni basati sull'intelligenza artificiale che possono assistere i consumatori via chat online)

-Si

-No

6.Se hai risposto SI, come valuti l'efficacia dei chatbots nell'aiutarti durante lo shopping online?

-Molto efficaci

-Abbastanza efficaci

-Poco efficaci

-Per niente efficaci

7.Se hai votato NO, ti fideresti di un chatbot che ti dia assistenza, consigli e raccomandazioni online?

-Si

-No

8.Credi che i chatbot possano essere efficaci come gli umani per fornire assistenza, raccomandazioni e consigli?

-Fortemente d'accordo

-D'accordo

-In disaccordo

-Fortemente in disaccordo

9. Motiva la tua risposta

---

10. Hai mai sentito parlare della funzione "ricerca fotografica" nelle app di abbigliamento? (la ricerca fotografica permette di caricare o scattare una foto di un prodotto che ti piace e l'app mostrerà prodotti simili)

-Si

-No

11. Se SI, hai mai utilizzato questa funzione?

-Si

-No

12.Ti sono mai apparse le raccomandazioni personalizzate quando fai shopping online?

-Sempre

-Spesso

-Raramente

-Mai

13.Quanto trovi utile ricevere raccomandazioni personalizzate durante lo shopping online da 1 a 10? (1=per niente utile – 10=molto utile)

14. Hai mai sentito parlare degli smart mirrors? (cioè specchi intelligenti tecnologici con elementi digitali e interattivi)

-Si

-No

15. Proveresti lo smart mirror se fosse già disponibile in negozio?

-Si

-No

16. Se dovessi valutare l'esperienza complessiva di shopping con l'uso di queste tecnologie, quanto la consideri positiva?

	Molto positiva	Positiva	Negativa	Molto negativa
Virtual try-on	○	○	○	○
Assistenti di stile virtuali	○	○	○	○
Chatbots	○	○	○	○
Ricerca fotografica	○	○	○	○
Smart mirrors	○	○	○	○

Sezione 4 - Grado di preoccupazione sull'uso di queste tecnologie

1.Sei a conoscenza del fatto che i brand utilizzino i tuoi dati personali per fornirti raccomandazioni personalizzate, email e annunci mirati alle tue esigenze?

-Si

-No

2.Sei d'accordo che i brand utilizzino i tuoi dati personali (email, num telefono, cronologia acquisti) per fornirti raccomandazioni personalizzate?

- Si, sono d'accordo

- No, non sono d'accordo

3.Quanto sei preoccupato di condividere le tue informazioni personali (email, n.tel, preferenze) durante lo shopping online per ottenere raccomandazioni personalizzate?

-Molto preoccupato

-Abbastanza preoccupato

-Poco preoccupato

-Per niente preoccupato

4.Hai fiducia a dare i tuoi dati personali ai brand dai cui acquisti regolarmente?

-Si

-No

5.Ti è mai capitato di cercare un prodotto online e poi vedere annunci simili anche su altre piattaforme?

-Si, spesso

-Si, occasionalmente

-Si, raramente

-No, mai

6.Come ti fa sentire il fatto che i brand sappiano esattamente ciò che vuoi?

-Non ho preoccupazioni, sono tranquillo/a

-Ho qualche preoccupazione, mi sento controllato/a

-Ho molte preoccupazioni riguardo la mia privacy

-Ho molte preoccupazioni, vorrei non riceverle più

7.Daresti ai brand l'accesso temporaneo alla tua fotocamera per provare virtualmente vestiti e accessori? (Per esempio tramite l'app ufficiale del brand)

-Si

-No

8. Daresti l'accesso ai filtri Instagram o TikTok per provare virtualmente vestiti e accessori dei tuoi brand preferiti?

-Si

-No

9.Daresti l'accesso agli specchi intelligenti collocati in negozio per vedere come i vestiti ti starebbero senza indossarli e scattare foto?

-Si

-No

10.Compileresti un quiz di stile (taglia, colori, stile) per avere un chatbot virtuale che ti consigli abbinamenti e consigli di stile?

-Si

-No

11.Quanto sei preoccupato da 1 a 10 che enti terzi possano violare i tuoi dati personali, di pagamento e foto?

(1=per niente utile – 10=molto utile)

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