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How AI can revolutionize modern industries: an analysis of the strategic and ethical implications in business and healthcare

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"What is perhaps at the core of the experiences we create, and the applications that we create, as well as the platform itself is AI. AI is the runtime that is going to shape all of what we do."

- Satya Nadella, Microsoft CEO

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Abstract

We live in a world that changes every day: change is part of our nature. Artificial Intelligence, commonly referred to as AI, embodies the concept of change and it is the driving tool of innovation. Together with Machine Learning, Big Data, and the Internet of Things, AI is revolutionizing how people live and conduct business. This work aims at analyzing the impact of Artificial Intelligence and its main applications in the world of business and healthcare.

The adoption of AI systems is increasing at a fast pace across many industrial sectors, leaving plenty of opportunities for economic growth and profit. In particular, AI is having a strong impact on e-commerce and healthcare, and it is about to reshape the concept of work as we know it. AI is transforming how care is delivered, pathologies are diagnosed, and treatments are provided. The increasing investment in R&D is enhancing drug discovery and speeding the life expectancy of people. However, the exponential benefits that may be achieved through the deployment of AI algorithms depend on the quality of the data. Big Data is the lifeblood of AI, without which AI algorithms are useless. More data means higher liability for enterprises, and several debates have been raised. Ethics, in fact, is a challenging topic, especially when talking about AI. Companies must be able to incorporate ethical AI in their business processes, protecting customers' rights while driving innovation.

AI has shown to be a powerful tool, but it is not meant to substitute workers, rather aid them. Thanks to AI, more skills will be developed, new jobs will be created, and a new workforce will emerge, benefiting the whole society. In addition, AI is changing how cities are structured, and disruptive technologies are the key to fuel economic growth. Executives must embrace change and not fear it. This means adopting a proactive strategy in the first place, being able to identify opportunities and pursue them before competitors. Competition itself will be redefined, since AI-powered firms can outpace traditional operating models. That being said, a correct deployment of AI is only possible if the corporate culture of the company is perfectly aligned throughout the enterprise and everyone is on the same page.

Introduction

The adoption of Artificial Intelligence is booming around the world. AI has the potential to boost industry profits and promote innovation while driving down costs. In three chapters, this analysis discusses the disruptive power of AI, which can generate huge opportunities, but it also involves significant challenges. Companies must be able to address both of them and find the right balance to correctly implement AI instruments while protecting customers. Being successful with AI means having a data-driven culture that embraces a deep technological background.

In the first chapter, the concepts of Artificial Intelligence, Big Data, and the Internet of Things are introduced. In particular, it is fundamental to understand that these technologies do not operate in a vacuum, but they jointly create a dynamic environment that promotes innovation and productivity. High-quality data is the main requirement for a successful implementation of AI techniques, which can foster prediction and improve decision-making. In addition, a brief historical background is presented, from Alan Turing to nowadays. Having a solid background is useful to understand the development of Artificial Intelligence and the evolution of Machine Learning and Deep Learning concepts.

The second chapter describes the impact of Artificial Intelligence in several industrial sectors. The discussion aims at pointing out what are the most profitable areas for AI and how a company should formulate its strategy to benefit from the use of AI at scale. In particular, retail, e-commerce, and healthcare are referred to as some of the most promising industrial sectors in which AI can make a difference. In fact, through the handling of massive amounts of data, AI systems become more efficient and accurate, creating new value for both enterprises and customers. Prediction is the key element of AI, and tech-giants such as Amazon, Apple, and Facebook are investing heavily in AI instruments to optimize their business processes. Besides, AI-enabled solutions are changing how business is defined, care is delivered, and cities are structured.

Chapter three encompasses the concept of ethics and describes how AI should incorporate it. The consequent impact on stakeholders and the risks associated with the implementation of such technology are presented through concrete examples. Privacy issues, lack of resources, and discrimination problems are some of the reasons why companies are failing to implement ethical AI and need to update their current strategy.

Furthermore, the automation process will be deeply discussed in order to show how AI will impact productivity, job replacement, and the working class. Through this analysis, it will be possible to notice the final effect on society, thanks to a higher quality of services and increased productivity.

The final part of the work is dedicated to the COVID-19 pandemic. In particular, it describes how AI can be fundamental to fight the novel coronavirus, including faster diagnosis, contact tracing, social control, and workplace safety.

Chapter 1. Artificial Intelligence, Machine Learning and Prediction

1.1 Artificial Intelligence: definition and implications

Many organizations aspire to have cultures that embrace data analytics and other new technologies to gain insight into new ways of doing business, or to exhibit a new kind of operating architecture which redefines how they create, capture, and deliver value.

There are many and varied definitions of what Artificial Intelligence (AI) is, but it is very difficult to find a unique statement that satisfies everyone's needs.

Sometimes terms like Artificial Intelligence and Machine Learning are used interchangeably and yet, they are not the same thing, although they are strictly correlated.

Machine learning is the use of mathematical procedures to analyze data. These mathematical procedures are defined as algorithms and are the brain of artificial intelligence. The aim is to discover useful patterns, such as relationships or correlations, between different items of data. The key point about algorithms is that they tend to "learn" over time: the idea is that whenever you "feed" a machine learning algorithm more data, its modeling should improve, as well as the quality and the efficiency of the processes carried on.

Prediction is another crucial concept that is often associated with AI. The reason behind this correlation is that AI is based on prediction techniques, which fall under the name predictive analytics. Our Social Media accounts provide us with the content we are interested in, our banking apps provide us with reminders, and tech-giants like Amazon are even starting to predict what we will order before we even think about it. Prediction helps to make better and more accurate decisions, and this is what managers are concerned with.

As a matter of fact, Artificial Intelligence includes everything we have already mentioned, from machine learning to prediction, but, for the purposes of this thesis, the one definition we shall adhere to is:

«Artificial Intelligence (AI) is the replication of human analytical and/or decision-making capabilities. This includes learning, planning and problem-solving. AI applications can perform as well or even better than the average person when faced with everyday tasks. »[1]

According to John Searle, it is necessary to distinguish between two forms of AI:

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[1] Steven Finlay. (2018). Artificial Intelligence and Machine Learning for Business: A No-Nonsense Guide to Data Driven Technologies, Third Edition, Relativistic.

- *Strong AI*: this type of AI deals with machines that can actually think and carry on tasks on their own, just as human minds do. There may even be emotions and creativity and only a few companies focus on this category, such as Google's DeepMind;
- *Weak AI:* this type of AI represents a machine that is pattern matching and usually focused on narrow tasks. Examples of this include Amazon's Alexa, Google's assistant and Apple's Siri, which simulate human behavior.

AI is a tool that can really change the rules of the game. This is not just about business, but a number of different industries: healthcare, retail & e-commerce, banking & finance, logistics & transportation, education, real estate, and even the travel & tourism sector.

Most of today's applications represent forms of weak AI and it is easy to understand the reason behind this interpretation. Strong AI, in fact, consists of a reproduction of autonomous human behavior, which is not only very hard to achieve, but also different from what a lot of companies wish to do with this technology.

Weak AI works as self-sufficient systems combined with algorithms that are able to solve issues belonging to a particular category. When this happens, the machine behaves as an autonomous intelligent device, even though it is more like a learning-based simulation of human intelligence, which can be either supervised or not. When supervised learning is applied, machines are taught to recognize both pictures and sounds straight from a database reflecting the kind of learning to be achieved, like recognizing a house in a series of images. This means that the machine is able to distinguish the single elements within a given context and is able to label them by analyzing each piece of data in the system. By doing so, the machine learns how to associate the picture/sound to its right meaning and slowly starts to recognize it by default, leading to non-supervised learning. The whole process is accomplished thanks to the concept of deep learning networks.

The important point to stress is that Artificial Intelligence is in our life, every day.

AI has already been largely adopted by the most important companies of the world and will revolutionize the concept of business in the broad sense. In particular, a lot of applications today concern automation, data analytics and natural language processing. In a large number of industries that are and will continue to be affected by AI, these are crucial operations that contribute to the improvement of several tasks, such as: the detection of potential frauds, a more efficient customer service, consumer behavior forecasting, product recommendations, and a more precise marketing service.

The industry of AI is growing rapidly, spawning new sectors and giving birth to new types of enterprises.

Growth of the artificial intelligence market worldwide from 2017 to 2025
Artificial intelligence market growth worldwide 2017-2025

Note: Worldwide; 2016 to 2017
Source(s): Tractica

Figure 1.1 – Tractica. (December 2018). Growth of the artificial intelligence market worldwide from 2017 to 2025. In Statista – The Statistic Portal. Released by Arne Holst.

There are increasing opportunities for AI, not only in business. According to several experts, AI is about to make a decisive impact on supply chain management, manufacturing and the marketing sector, but there is also opportunity for other types of companies in finance and banking.

In addition, healthcare is probably one of the industrial sectors that will be affected the most and has the potential to improve many aspects of the patient care, including the diagnosis of any diseases like cancer, more accurately and in earlier stages.

Whether we discuss about start-up or a traditional enterprise, it is essential to figure out the impact of AI on competition.

AI will boost industry profits and innovation. *«In particular, AI has the potential to boost rates of profitability by an average of 28 percent by 2035 and lead to an economic boost of US $14 trillion across 16 industries in 12 economies by 2035. This breakthrough will also affect the growth rates of*

a number of industries, where AI has the potential to increase economic growth rates by a weighted average of 1.7 percentage points. » [2]

It must be said that AI will drive growth by creating a new workforce, enhancing capital for the existing workforce, and by driving innovation. The development of new products will involve new techniques, 3D printing in particular, which is revolutionizing the world of manufacturing.

Source: Accenture and Frontier Economics

Figure 1.2 – Accenture and Frontier Economics. (2017). The impact of AI on industry growth. From "How AI boosts industry profits and innovation". Full Report by Mark Purdy and Paul Daugherty.

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[2] Mark Purdy and Paul Daugherty. (2017). How AI boosts industry profits and innovation. Accenture and Frontier Economics.

Generally speaking, AI will contribute to give new life to companies and business. Corporate profits have been consistently in decline, but AI has the power to redefine the terms of corporate growth and profitability. The key to fully exploit the potential of AI is to combine human and machine intelligence in order to create an open corporate culture that embraces innovation while being committed to moral and ethical values.

1.2 Historical Background

To have a complete understanding of AI, it is important to have a solid grounding in its historical background.

The technology of Artificial Intelligence has entered an exciting period, with great hopes for new developments and products. A large number of startups have started to operate in the AI sector and now are shifting to more mature funding phases.

Although the concepts of AI and machine learning have gained popularity in the last years, the technology behind them is far from new.

The term "Artificial Intelligence" was first coined by John McCarthy in 1956 during an academic conference at Dartmouth University. He called it a "study of artificial intelligence", where researchers Allen Newell and Hebert Simon contributed to promote AI as a field of computer science that could transform the world. Nevertheless, the journey to know if machines could actually think began much before that.

The brilliant British mathematician and code-breaker Alan Turing is commonly referred to as the father of both computer science and artificial intelligence.

In 1950, in his paper, called "Computing Machinery and Intelligence", Alan Turing discussed how to build intelligent machines and how to test their intelligence:

(i) *Turing Test*: it is essentially a game with three players: two that are human and one that is a computer. The evaluator, a human, asks open-ended questions of the other two (one human, one computer) with the goal of determining which one is human. If the evaluator cannot make a determination, then it is presumed that the computer is intelligent.[3]

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[3] Tom Taulli. (2019). Artificial Intelligence Basics: A Non-Technical Introduction. Apress.
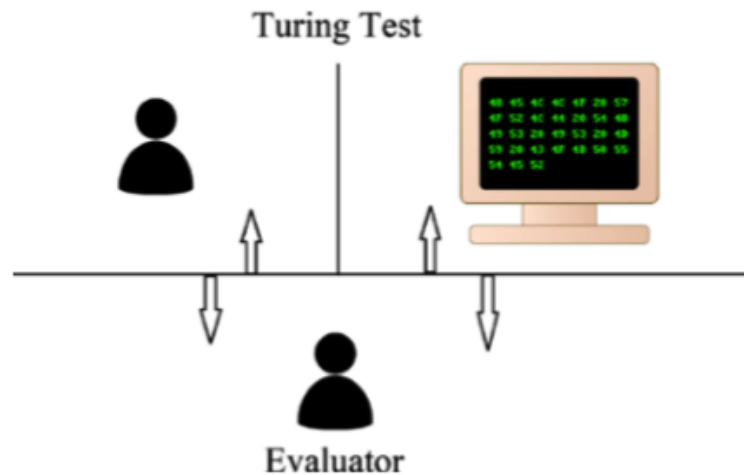
Figure 1.3 – Tom Taulli. (2019). The basic workflow of the Turing Test, Artificial Intelligence Basics: A Non-Technical Introduction, Apress.

From 1956 to 1974, AI flourished and during that period it was one of the hottest spots in the tech world. Computers could finally store more information and became faster, cheaper and more accessible. Indeed, machine learning algorithms became more sophisticated and showed improvements in recognizing the right patterns.

In that period, most of the funds came from the Advanced Research Projects Agency (ARPA), which was launched in the late 1950s.

In the first decades the main focus of AI was on intelligent tasks like the translation of languages and the game of chess, but, due to the difficulties in performing such activities, many of these challenges were not realized until 1997, when IBM's Deep Blue chess-playing program was able to beat Gary Kasparov, the top-ranked chess player in the world. However, for what regards the translation area, human translators still turn out to be better than any translation programs to our days.

Over the years, AI researches have made slow but constant progresses.

During the 1970s and 1980s computer scientists worked with peers from growing fields, especially cognitive science and knowledge engineering. These applications were aimed at capturing and testing the knowledge of the algorithms.

MYCIN, an early AI system, diagnosed infectious diseases and developed some recommendations for the kind of treatments that could be used.

Problem-solving and other general skills were also widely studied, along with the logic behind the prediction models in medicine and biology.

There was a lot of enthusiasm behind this kind of technology and the opportunities that it could create, but many people overestimated the time that people needed to improve the algorithms to install in the software.

The major breakthrough came in 2006 when researchers developed the *deep learning networks,* which allowed to train neural networks with many layers and, consequently, learn from experience like a human mind.

With deep learning, machines could finally be programmed to learn from data without a significant human effort to process or structure the data.

Now that we have introduced the concept of deep learning, we can understand the relationship between Artificial Intelligence, Machine Learning and Deep Learning.

Deep Learning can be considered a subset of Machine Learning, which, in turn, is a subset of Artificial Intelligence. AI emerged first, then the concepts of machine learning and deep learning contributed to a larger expansion and adoption of the technology that we know today.

Figure 1.4 – Nadia Berchane (M2 IESCI, 2018). Artificial intelligence, machine learning and deep learning.

In the following years exponential gains in computer processing power and storage ability allowed companies to store and crunch large quantities of data. In the past 15 years, Google, Baidu, Amazon, and others have leveraged on machine learning to their huge commercial advantage. In addition, the use of Big Data has allowed AI to go further and take the next step in its development.

From 2010 onward, Artificial Intelligence has become embedded in our day-to-day life, from virtual assistants to intelligent computers.

In 2011 Watson, a natural language question answering computer created by IBM, defeated two former Jeopardy! Champions, Ken Jennings and Brad Rutter, in a televised game. The machine could

not just spit out facts but also make connections between various sources it had digested to come up with the right answers.

In the same year Apple introduced Siri, a virtual assistant on the Apple iOS system. Siri uses a natural-language interface to communicate with the human user and recommend things to him in the best way possible. The key challenge of Siri was to pioneer a totally new way of accessing the Internet by excelling in natural language processing, so as to provide the customer with an individualized experience that could be able to understand perfectly his requests.

Nevertheless, Siri encountered some problems, as different people claimed that the service was not perfect. The service improved over the years and this led to a broader adoption.

The next step in the virtual assistant market was made by Amazon with the creation of Alexa, a smart home assistant that through speakers hears commands and performs subsequent actions. Thanks to Amazon, AI took a step ahead and was finally introduced in our everyday life.

AI has become extremely useful also in search engines to better aid the customer during the search process or to help him find the product he is looking for. Google's search engine and Amazon's recommendation system are embedded with AI, which scales to massive data sets and produces high-quality recommendation list for the user.

1.3 Big Data: the lifeblood of AI

Big Data describes a way to store and handle huge amounts of volumes of information.

With the ubiquity of Internet access, mobile devices, and wearables, there has been the unleashing of a torrent of data. Every second, Google processes over 40,000 searchers or 3,5 billion a day. On a minute-by-minute basis, Snapchat users share 527,760 photos, and on YouTube more than 4,1 million videos are played.[4] And the list goes on.

No business operates without collecting huge amounts of data. This is because through data companies get to know better their customers, their tastes, their preferences and learn to give them what they want, when they want it. In economic terms, data is a key complement to prediction and becomes more valuable as prediction becomes cheaper.

Most big companies like Amazon, Spotify, Google, Netflix, YouTube, and many others constantly collect and analyze user interaction data with their platforms. They run machine learning models to predict user demand and other behavioral patterns.

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[4] Tom Taulli. (2019). Artificial Intelligence Basics: A Non-Technical Introduction. Apress.

For instance, Google wants to provide users with the most relevant search results so that they never switch to another platform, while Netflix stores data about the kind of content they like watching to predict what they might like in the future.

Even if the quantity of data is very important to an organization, it is not the only characteristic that matters when talking about Big Data.

The volume, in fact, represents the scale of the data, which can be structured or unstructured (as it is often the case).

Another essential feature to take into account is variety. Collecting a more diverse set of data, say a combination of structured and unstructured, increases the chances of a better outcome in the process, but handling with so many different kinds of data can become a major challenge.

Unstructured data lack any specific format and include different elements, such as text, image, video, document, etc. This kind of data represents 90% of data created. On the contrary, structured data is data retrieved in a fixed format and with a given meaning. It refers to a collection of organized information that can be simply stored and accessed by any database.

In addition, data can also come from several different sources, such as web/social (Facebook, Twitter, Instagram), biometrics (fitness trackers, genetics), points of sale system (brick-and-mortar stores and e-commerce), Internet of Things (IoT), Cloud systems or corporate.

The third crucial characteristic is the velocity of data. The collection of data should be as fast as possible because otherwise, people will get frustrated and go somewhere else.

Because of these issues, velocity is probably the most difficult to accomplish.

One of the most significant advantages of Big Data is predictive analysis.

Everybody should agree on the fact that, right now, data is the most valuable asset of the world. Moreover, AI plays a crucial role in the execution of the strategies behind the information previously stored.

AI's ability to work so well with data analytics is the main reason why AI and Big Data are deeply linked to each other, merging into a synergistic relationship, where AI is useless without data and data is the lifeblood of AI.
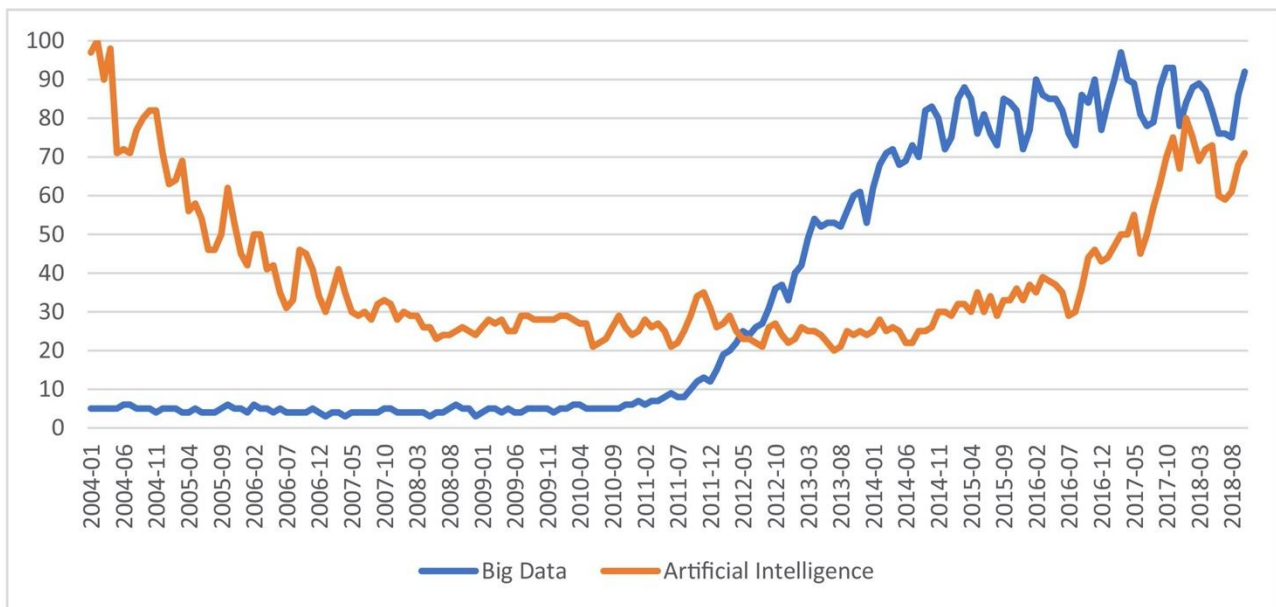
Figure 1.5 – Google Trends, (2018). By Z. Allam. Popularity of Big Data and AI from 2004 to 2018.

As the graph shows, Artificial intelligence has been in vogue since the 1950s, but it has not gained popularity until Big Data stepped in. As a result, AI is far more powerful with Big Data and the two technologies are complementary, due to a strong correlation between them.

Indeed, an analysis carried on by Google Trends in 2018 revealed that the peak in the adoption of Big Data had a positive impact on the use of AI instruments, which obtained popularity and became more accessible and powerful.

Being successful with AI means having a data-driven culture. This is what has been critical for companies like Amazon, Google, and Facebook. When making decisions, they look to the data first. There should also be wide availability of data across the organization.

1.4 Who owns Big Data: the people behind the algorithms

We already know that the information retrieved will be analyzed and then used by AI to solve complex issues and make decisions. That is what Big Data and AI are all about: improve decision-making.

However, there are several debates on how this kind of information is collected over time, and, most of all, who collects and manages it.

In principle, the idea that the AI systems are often too complex to explain the internal logic is false. Most of the time it is just a way to hide mistakes and ambiguities that might have a significant impact on the life of the people concerned.

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There is always a human mind working behind AI algorithms, and the accuracy of the software depends on the quality of the data previously stored in the system.

AI always involves some kind of trade-off, and very often it is difficult to distinguish between a right and wrong decision because it can involve ethics, which is really a difficult topic to define.

Behind Amazon's Alexa, as well as Apple's Siri and Google's search assistant, there are actual people in the flesh who program the software that will then interact with the end-user.

Hence, there is this ambiguity behind AI that people are scared of: people's privacy might be at risk. It happened several times that companies, even very famous ones, failed to protect the personal data of their customers. The biggest scandal is probably the Facebook-Cambridge Analytica case. It was revealed that Cambridge Analytica had harvested the personal data of millions of people's Facebook profiles without their consent and used it for political advertising purposes, causing a huge fall in Facebook's stock price. The company also came under pressure from the US and the European Governments.

Likewise, in the late 2018 another great scandal involving Google broke out. Google engineers discovered a software leakage within the Google+ API used in the social media network: over five million users' data was compromised.

What it is meant to show with these examples is that Big Data is a big issue and, as such, it is very difficult to deal with. There is a great sense of ambiguity behind who manages this information, since companies are not always transparent in the policies regarding the management of the data. And the ambiguities behind these problems might not be just technical, but also legal and behavioral.

We should ask companies to give further explanations about the logics and the mechanisms that compose the system, because the only way to understand how AI works is to understand the choices, the evaluations and the trade-offs made in principle by the people that created the system and that influenced the functioning of the algorithms.

Transparency can help mitigate issues of fairness, discrimination, and trust, which are receiving more and more attention. This is one of the main trade-offs behind AI: on the one hand, by collecting this enormous amount of information AI might create real benefits, but, on the other it could create new risks. To mitigate these risks, organizations will need to pay attention to how they manage the information they collect and share.

When talking about data, most of the people usually assume that more data is always better, but this is not true for risk management, in which data represents a sort of liability.

The protection of data and the adoption of policies that are completely "transparent" come with a cost which might be in the form of a lower profit (at least for some time) or a lawsuit, if something goes

wrong. For this reason, it is crucial to hire lawyers to assist engineers in the creation of AI, in order to avoid any kind of legal issue that might be controversial to the purpose of the organizational project and that could put the final outcome at risk.

Every decision-making system assisted by AI is developed by humans to reach a given goal. This goal is not determined by AI, but by the people that develop the algorithms, and this is the reason why it is important to recognize the right patterns for which the system was generated.

From the firm's point of view, there are different ways of handling Big Data and information in general.

For example, Amazon is well-known for being the biggest retailer in the world, but not everyone knows that it is also the best company in the cloud computing market, with probably the leader platform of the sector: Amazon Web Services. The platform offers over 175 fully featured services from data centers globally and millions of customers – including the fastest-growing startups, largest enterprises, and leading government agencies- are using AWS to lower costs, become more agile and innovate faster.

On the other hand, a company can decide to rely on third party's software to better explore, analyze and share business analytics. For example, in the summer of 2019 Google announced the acquisition of Looker, which is one of the best companies in the big data management field. The transaction value was around $2.6 billion and aimed at empowering the Google Cloud platform, making it more attractive in the competition with other big players in the Cloud market, such as Amazon Web Services (AWS), Microsoft Azure and IBM Cloud.

1.5 The Internet of Things

The concept of the Internet of Things (IoT) goes along with Big Data and Artificial Intelligence.

«The Internet of Things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction».[5]

Together with AI, the IoT will fundamentally change all industries, from agriculture to transportation and healthcare, up to the point that nearly everything in our world will become connected in the next

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[5] Margaret Rouse (2020). IoT Agenda, https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT

few decades. IoT devices record and transfer data to monitor relevant processes, boost efficiency and give new insights, allowing companies to make more informed decisions.

The IoT market – which includes hardware, software, system integration, and data and telecoms services – is expected to grow to \$520 billion by 2021. That figure represents more than 100 percent rise on the \$235 billion spent in 2017.[6]

The successful combination of AI and IoT is crucial because it enables businesses to collect data in the real world from several instruments, such as wearables, sensors, and other appliances, and deliver a better outcome based on the information collected. In other words, AI is the brainpower of technology that makes IoT devices more useful.

The synergistic relationship between Artificial Intelligence and the Internet of Things is turning many industries around, changing the way in which they approach and interact with their end customers. This digitalization shift can create a disruption within every industry, and this is true whether the organization wants to improve customers' experiences, boost productivity, or obtain data analytics with predictions and insights. This combination creates a dynamic environment that promotes the welfare of both companies and customers, where companies learn how to better satisfy customers' needs and customers get what they desire. This is accomplished through the possibility to retrieve high-quality data and apply the information in the real word, enabling companies to act in a perfect ecosystem, where suppliers, employees and customers become intertwined.

The reason why it is important to stress the relationship between these technologies is that firms must take into account that they must not be used in isolation. AI, IoT, and Big Data jointly create an ecosystem of automation. Therefore, they need to be implemented together. The mechanism usually follows this pattern: IoT devices collect data, which are then transferred in the cloud and used to train and improve AI algorithms.

There are a lot of business industries in which IoT can play a crucial role and help a company achieve a competitive advantage, starting from marketing up to the healthcare industry.

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[6] Andrew Hobbs. (2018). Internet of Business. Five ways the Internet of Things is transforming businesses today.
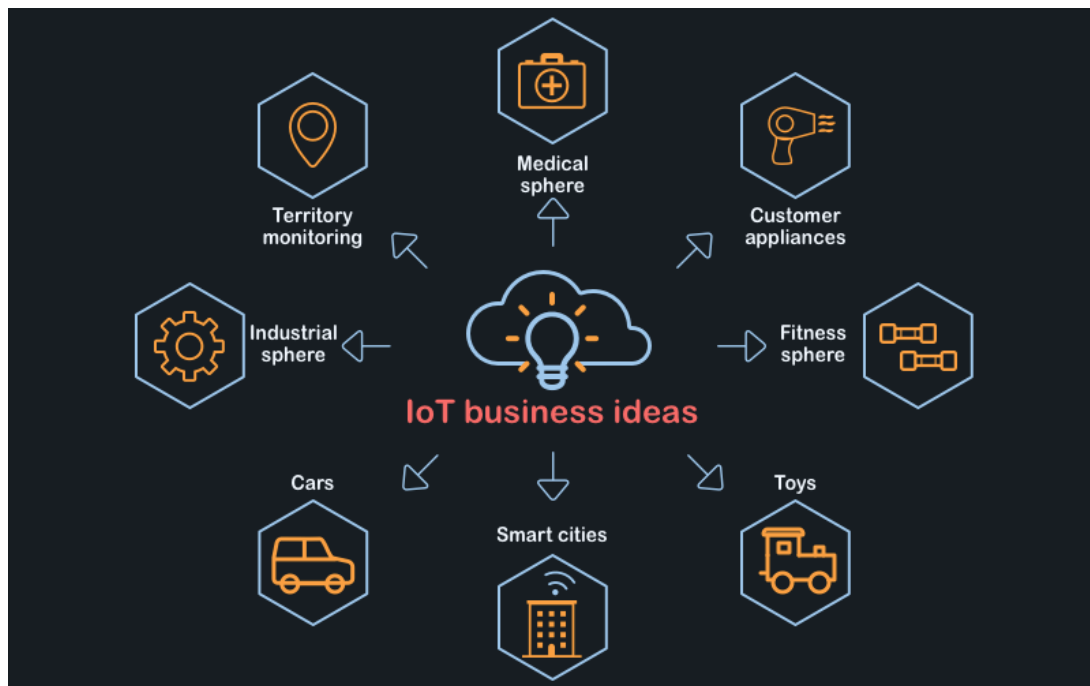
Figure 1.6 – Daria R. Cleveroad. (2019). Internet of things business ideas.

The most interesting business ideas are probably the ones representing *Smart Cities* and *Self-Driving cars*. These concepts are deeply interconnected and involve similar issues.

With the aid of technology, Smart Cities could revolutionize the concept of city as we know it, introducing smart shops, smart traffic lights, railway-crossing, and roadside sensors collecting information about sounds.

At the same time, smart cities could enhance the adoption of autonomous vehicles, which, in turn, could greatly improve their performances by integrating data from them. Instead of computing an incredible number of calculations and prediction analyses about traffic patterns, autonomous cars might simply receive this data and use it to make real-time decisions without overwhelming the system.

These decisions are all linked by the need to develop an infrastructure that is able to contain such elements because, without it, nothing can exist.

The best part is that basically all these industries still represent a niche in the market, leaving plenty of opportunities to make profits and establish a significant position in the market.

The difficulty lies on the fact that the sunk costs required to develop such ideas are very high and there are also remarkable legal implications to keep in mind.

Furthermore, bright prospects of the Internet of Things make it hard enough to forecast all possible imperfections. Nevertheless, developers are aware of the fundamental issues that can prevent IoT from being a world-spread concept as it is aimed to be.

Nowadays, the main problems related to this technology regard safety regulations, especially in the user's private life: starting from unauthorized access to any home-device, finishing with calculation of medication dosages and free admission to money resources from any outsider who has access to the application.

Another problem of IoT is energy efficiency, and with this, the development of an ecosystem that is resilient and, at the same time, flexible.

Chapter 2. The Revolution of Artificial Intelligence

2.1 AI adoption by industry

Despite relying on traditional business practices operated by people in the flesh, say workers, engineers or managers, companies and industries rely on algorithms and, in particular, on the value they might get from them.

It is important to state that the value created and then delivered is designed by the people behind these algorithms and the data previously stored in the software, as already mentioned in Chapter 1. However, shortly after that, the system starts to generate value by itself, thanks to either digital automation or a network of providers outside the enterprise.

The elimination of traditional constraints revolutionizes the concept of competition and the rules that govern it. As digital networks and algorithms are woven into the fabric of companies, industries start to function differently and the lines between them blur to the point that there are no sharp boundaries. Whether we discuss about start-up or a traditional enterprise, it is essential to figure out the impact AI has on strategy and competition.

According to a recent survey carried on by McKinsey & Company, the adoption of artificial intelligence (AI) is rapidly taking hold across global business.

AI, typically defined as the ability to perform cognitive functions usually associated with human minds, can solve significant business issues by means of a number of capabilities. In particular, nine abilities have been discussed in the survey, where respondents expressed different points of view. Almost half of them sustained that AI was employed in at least one of their main business processes, whereas another 30% reported a piloted use of AI. Nevertheless, many organizations still lack the foundational practices to create value from AI at scale – for example, mapping where their AI opportunities lie and having clear strategies for sourcing the data that AI requires.

Exhibit 1

AI seems to be gaining the most traction in the areas of the business that create the most value within a given industry.

Business functions in which AI has been adopted, by industry,[1] % of respondents

	Service operations	Product and/or service development	Marketing and sales	Supply-chain management	Manufacturing	Risk	Human resources	Strategy and corporate finance
Telecom	75	45	38	26	22	23	17	15
High tech	48	59	34	23	20	17	21	17
Financial services	49	26	33	7	6	40	9	14
Professional services	38	34	36	19	11	15	16	11
Electric power and natural gas	46	41	15	14	19	14	15	14
Healthcare systems and services	46	28	17	21	9	19	18	13
Automotive and assembly	27	39	15	11	49	2	8	6
Travel, transport, and logistics	51	34	32	18	4	4	2	3
Retail	23	13	52	38	7	9	8	0
Pharma and medical products	31	31	27	13	28	3	6	4

[1] This question was asked only of respondents who said their organizations have piloted or embedded at least 1 AI capability in 1 or more functions or business units. Respondents who answered "don't know" or "none of the above" are not shown. For telecom, n = 77; for high tech, n = 215; for financial services, n = 306; for professional services, n = 221; for electric power and natural gas, n = 54; for healthcare systems and services, n = 67; for automotive and assembly, n = 120; for travel, transport, and logistics, n = 55; for retail, n = 46; and for pharma and medical products, n = 65.

Figure 2.1 - McKinsey & Company, (2018). Notes from the AI frontier: AI adoption advances, but foundational barriers remain.

For what concerns the specific industrial sector, telecom, high-tech and financial services companies are leaders in overall adoption. Results show that AI is employed in the business areas that generate more value in terms of money, being more attractive when looking through sectors and functions within a given industry.

For instance, if we consider the retail industry, AI is widely adopted in marketing and sales transactions, as it is stated by 52% of the respondents, compared with 29% of the total survey. (Figure 2.1).

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Digitization is essential for a correct use of AI in business processes. The survey shows that companies with a broad digital culture tend to deploy AI in more business functions than companies that do not embrace digitalization. In fact, digitization is the key enabler that allows companies to benefit from AI at scale. In addition to that, other foundational activities contribute to the creation of value in that sense.

Having said that, it is possible to provide some recommendations for a correct deployment of AI. Companies ought to take the following steps to maximize the power of Artificial Intelligence (at scale):

- *Make progress on digital journey*: companies that do not have a strong digital structure cannot benefit from the use of AI at scale due to the lack of training data, which are essential for the creation of superior AI systems. Digitization enables businesses to optimize the use of AI and gives them the ability to transform superior AI insights into behavioral changes at scale.

- *Scale AI's impact across the enterprise:* a keen awareness and commitment of leaders are required to drive disruptive changes within the company. The findings show that AI is still not embedded in multiple functions or business units. Roughly one-third reports to only piloting the use of AI. Therefore, enterprises need to do more than just distributing skills across the company.

- *Put key enablers in place*: according to the survey, the creation of value is related to the presence of some foundational enablers. Such enablers include the support of top management, the creation of a company-wide portfolio of AI opportunities, the introduction of a sophisticated data strategy and action to close out skill gaps.[7]
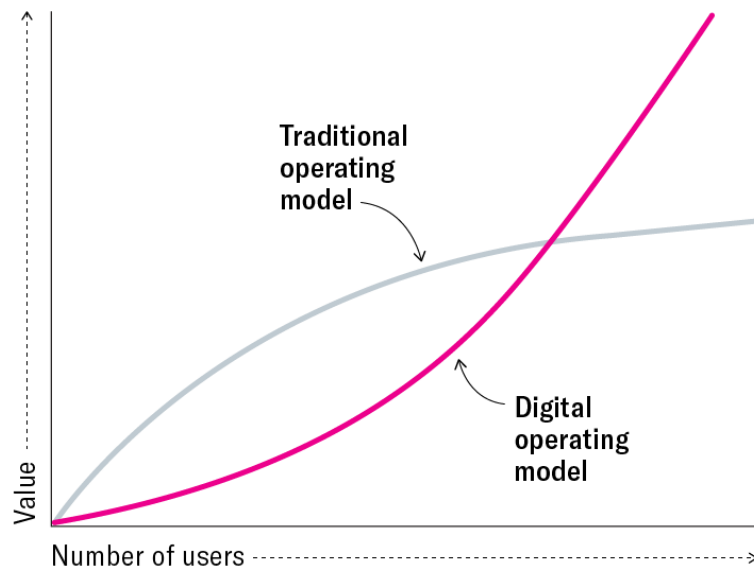
The survey is useful to contextualize AI in a broader background and makes us understand that to be successful with AI a company must build a culture that embraces a deeper technological background.

As AI-powered firms start engaging in competition with traditional businesses, the concept of competitive advantage assumes new shape and meaning.

What adds value to AI adopters is that with AI any process can be scaled much more rapidly than in a traditional environment and this, in turn, can allow for much greater scope, leaving powerful opportunities for learning and improving.

In traditional operating models, scale inevitably reaches a point at which it delivers diminishing returns, while this might not necessarily be the case in AI models.

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[7]All the information is taken from: McKinsey & Company. (2018). Notes from the AI frontier: AI adoption advances, but foundational barriers remain.

From: "Competing in the Age of AI," by Marco Iansiti
and Karim R. Lakhani, January–February 2020

▽ HBR

Figure 2.2 – Harvard Business Review. (February 2020). From "Competing in the Age of AI", by Marco Iansiti and Karim R. Lakhani.

As the figure shows, the return on scale can continue to climb to levels never reached before. Consequently, it is not a surprise that in a 2019 Accenture poll, 85% of executives working for the most important companies of the world said that they expect to invest heavily on AI in the next three years. However, the quality of the final results will depend upon the quality of the data, which must be coordinated across all operations (Accenture Technology Vision, 2019).

The successful outcome of AI on the operations of the company can be predicted by the level of commitment of the company towards this goal. This suggests that AI can really express its potential only if firms adopt a proactive strategy and build a corporate culture that embraces the concepts of AI, Machine Learning and Big Data. The same reasoning applies for the analysis of the future profit margins.

As Figure 2.3 shows, AI adopters with a proactive strategy earn higher profit margins, roughly 15% more than the industry average. In addition to that, the pattern is expected to increase by approximately 5% in the near future (in about three years from adoption), when the company will truly start to benefit from the investment made before.[8]

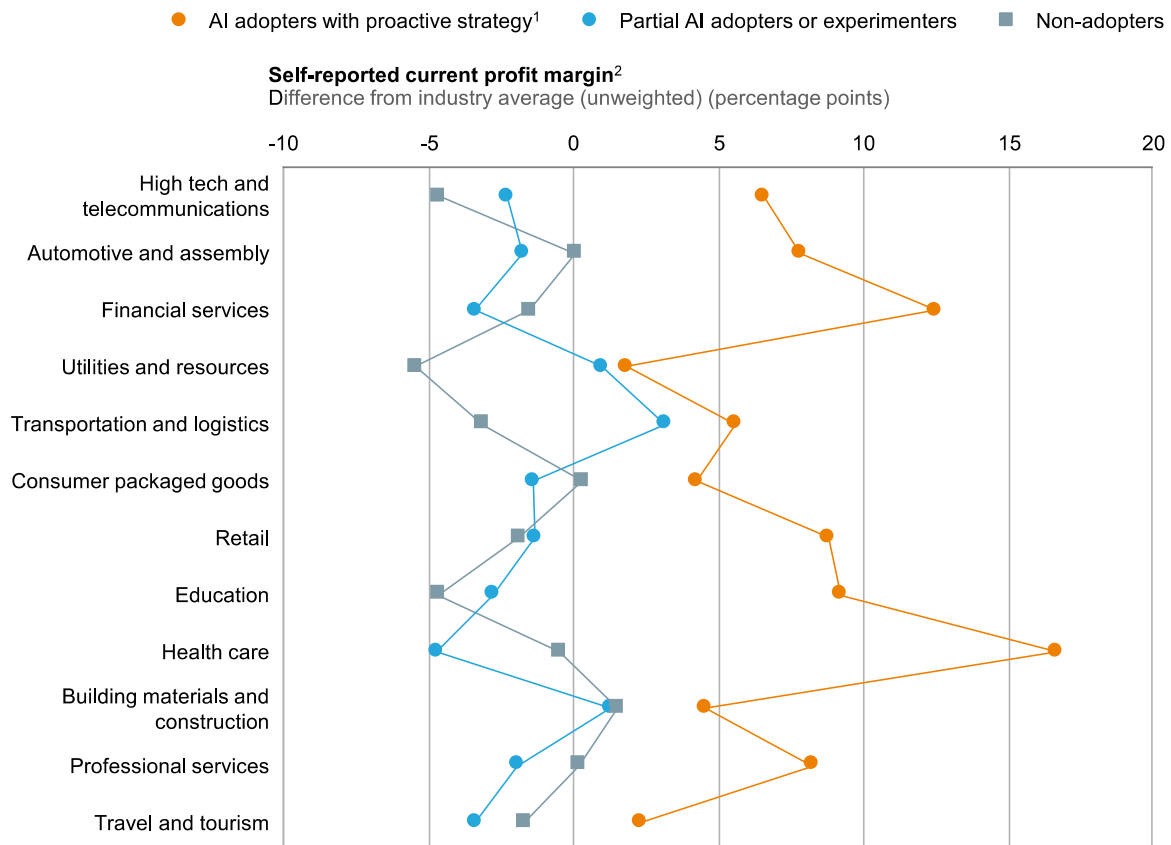Companies that invest in AI will be able to reduce costs and increase revenues at the same time, and even enhance asset utilization. In particular, the benefits will be embodied by the abilities to better forecast the demand for a given set of goods & services, the ability to offer higher quality at a lower

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[8] McKinsey Global Institute. (2017). Artificial Intelligence: The Next Digital Frontier.

price, the ability to enhance promotion and, finally, the ability to reach the right customer at the right time.

AI adopters with proactive strategy[1]   • Partial AI adopters or experimenters   ■ Non-adopters

Self-reported current profit margin[2]
Difference from industry average (unweighted) (percentage points)

	-10	-5	0	5	10	15	20
High tech and telecommunications							
Automotive and assembly							
Financial services							
Utilities and resources							
Transportation and logistics							
Consumer packaged goods							
Retail							
Education							
Health care							
Building materials and construction							
Professional services							
Travel and tourism							

1 Firms that are big data and cloud services users and report their strategic posture toward AI to be: "Disrupting our industry using AI technology is at the core of our strategy," "We have changed our longer-term corporate strategy to address the AI threat or opportunity disruption," or "We have developed a coordinated plan to respond to the AI threat or opportunity but have not changed our longer-term corporate strategy."
2 Operating profit margin for selected sectors as a share of turnover, for continuing operations and before exceptional items.

SOURCE: McKinsey Global Institute AI adoption and use survey; McKinsey Global Institute analysis

Figure 2.3 – McKinsey Global Institute. (June 2017). AI adoption and use survey. McKinsey Global Institute Analysis.

The aim is always to create value for the final customer, but what changes is how value is created and the way it is delivered. In other words, what changes is the value proposition for the client. Industries are being characterized by collisions between AI-firms and traditional firms and operations are getting more and more sophisticated to better satisfy the needs of their target markets. Some of them are even experiencing a strong segmentation, which means more needs to satisfy and more actions to put in place. But, most of all, this means to create more ways to deliver value.

To explain what it is meant for value, the best thing to do is to talk about a firm that has completely revolutionized the concept of value for its final customers.

Let's consider the Amazon case. Nowadays, Amazon is hardly impossible to define, since it has revolutionized a number of industries and the trend is not going to stop. But, if there is one thing for sure, there is no company on earth that values customers as well as Amazon does.

Amazon uses its large network and transportation capabilities to beat everyone on shipping performances. Through a superior online experience and excellent customer service, Amazon makes it really costly to compete. When talking about value, Amazon is leader. In fact, it is maybe the only company that is able to provide an excellent service both in terms of creation and delivering of value.

2.2 Predictive analytics: the power of AI

We have already introduced the concept of prediction, but now we are going to analyze it more deeply in order to understand how it can really create value for companies.

Prediction is the process of filling in missing information by taking the data already present in the system and generating new information. In particular, predictive analytics has been defined as the process of using data, modelling, and statistics to make successful predictions. Predictive analysis (PA) and Artificial Intelligence (AI) aim at increasing sales while enhancing customer satisfaction, providing customers with more personalized content over time.

Machine learning algorithms process past experiences (large amount of historic data) and feed new data into the system to create fresh predictions going forward. The result is a better assessment of the phenomenon and, consequently, an improvement in decision-making.

Prediction itself is costly, but AI is what can make it cheaper and more accessible.

Most people are familiar with shopping at Amazon.com. Right now, Amazon's business model is shopping-then-shipping, meaning that customers go to the website, select an item they wish to buy, they place it in the cart, and then pay for it.

Amazon will keep collecting data about its customers up to the point that it will manage to ship them the product they desire before they even order it. The prediction process will reach such a high level of accuracy that for Amazon it will be more profitable to ship the goods before customers place the order. In other words, Amazon will skip the shop step and will directly deliver the product.

Cranking up the prediction dial changes Amazon's business model from shopping-then-shipping to shipping-then-shopping.[9]

Even though most people could think that this is something futuristic or simply not feasible in a foreseeable future, Amazon started working on predictive analysis and the corresponding algorithms several years ago. To this regard, in 2013 Amazon obtained a US patent for "anticipatory shipping". The patent is described as follows: "*A method and system for anticipatory package shipping are disclosed. According to one embodiment, a method may include packaging one or more items as a package for eventual shipment to a delivery address, selecting a destination geographical area to which to ship the package, shipping the package to the destination geographical area without completely specifying the delivery address at time of shipment, and while the package is in transit, completely specifying the delivery address for the package.*"[10]

The logistics procedures and the final destination of the packages could be determined at the end of a deep analysis of business variables, and surveys/questionnaires might be used to successfully individuate the right customers. The patent then describes how to re-route packages based on the position of potential customers, who may decide in a second moment to purchase the product.

The key to anticipatory shipping is to create a system in which shipping-then-shopping method is effective in the sense that more customers enjoy benefits and a very little number of items is returned. In economic terms, this concept means that ROI must be maximized. It might be the case that the cost of returning an item is too high and then the ROI for shipping-then-shopping is lower than the ROI for the traditional approach. So, Amazon should pay attention to every kind of item and analyze every situation separately, which means a massive amount of work and data to interpret.

Another crucial step would be to modify the business structure of the company: a vertical integration may be successful in aiding return issues and increasing efficiency in handling returns, with trucks and transports specialized in that service.

The drop in the prediction costs will impact the utility of other elements, increasing the value of complements (such as data, judgment, and action) and diminishing the value of substitutes (human prediction).

In order for Amazon to be successful, AI should become capable of predicting customer demand so as to avoid the risk of potential returns of merchandise, which are very costly to a company.

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[9] Ajay Agrawal, Joshua Gans, Avi Goldfarb. (2018). Prediction Machines: The Simple Economics of Artificial Intelligence. Harvard Business Review Press.
[10] Google Patents. Method and system for anticipatory package shipping. https://patents.google.com/patent/US8615473B2/en

Having said that, it is very tough to imagine a totally foolproof system, where no mistakes are made. Hence, Amazon will probably start with this experiment way before its systems are 100% accurate. At the beginning, it could start shipping small packages, maybe using overstocked items in a warehouse. Then it could proceed by creating an algorithm that includes the number of people that like the product and decide to keep it, as well as the remaining people that decide to give it back. By the way, AI is also being used for enhancing traditional tasks, including inventory management.

2.3 Retail and E-Commerce: Amazon vs. Walmart

Amazon and Walmart are two of the largest retailers in the world and they are constantly in competition for new offerings and innovations. However, when it comes to strategy, they have always made different choices.

In particular, the main difference refers to the fact that Amazon is the absolute leader in the online market, while Walmart is dominant in the physical space, with over 11700 shops in 28 countries. But, recently, both brands have made substantial investments in the fields in which they were in a weak position with respect to the competitors, so the level of competition is expected to increase in the next years.

Recently (2019), it was announced that Amazon had surpassed Walmart as the world's largest retailer and, for the first time, Amazon profits exceeded Walmart.
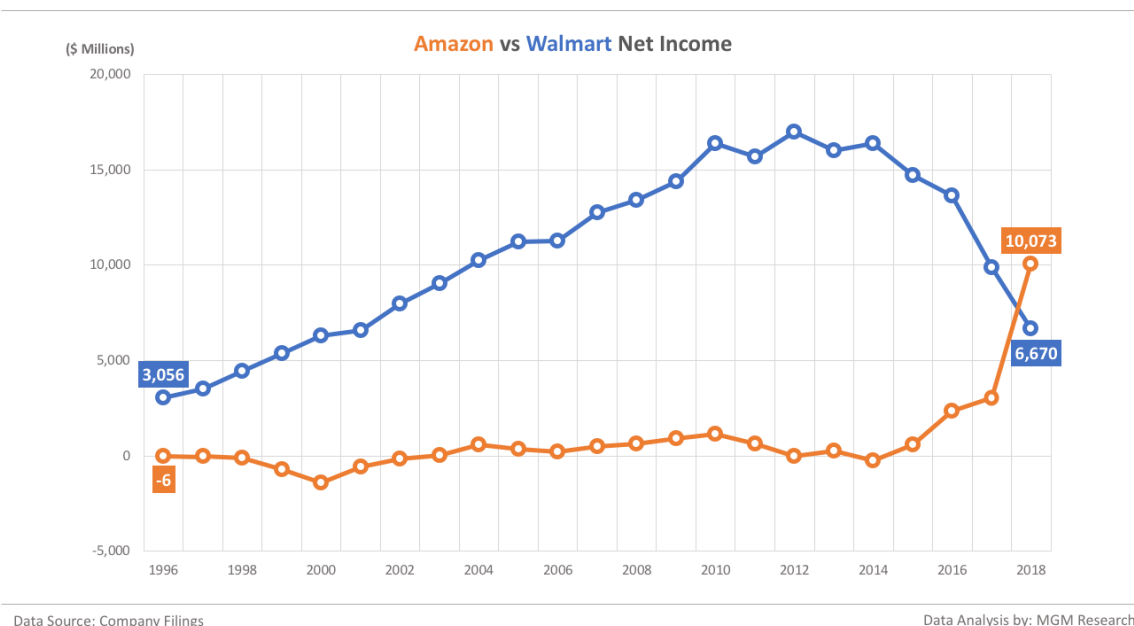

Figure 2.4 – Company Filings. (2019). Data Analysis by MGM Research.

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The chart shows the profits of both companies for the 23-year period from 1996 to 2018, where we can see that Amazon has always been smaller in terms of net profits until 2018, when the trend was inverted.

The two most important retailers of the world have different visions of how Artificial Intelligence will shape the store of the future.

On the one hand, Amazon first introduced the idea of a cashier-less store in 2016 with the opening of the first "Amazon Go" store in Seattle, near to the company headquarters. The aim was to minimize any kind of friction in the brick-and-mortar experience.

Amazon Go represents a new kind of store, in which customers can simply pick the items they want to buy and then walk out from the store by simply swiping their smartphone on a device, without any cash or queue to wait for. The only requirement is an Amazon account, which can be also accessed from the Amazon go App.

The combination between Artificial Intelligence, computer vision and data collected from multiple sensors is similar to the one used for self-driving cars. Computer vision allows to process data and track users when browsing into the store. Contemporarily, weight and motion sensors help assess the movement of a particular item in the store, but a system like this can also be vulnerable and lead to mistakes, especially when the store is crowded.

In the same way, Walmart has been developing new AI assets to build a similar concept. The result is Walmart's new Intelligent Retail Lab (IRL). Like Amazon Go's, the store has an impressive array of sensors and cameras to aid product inventory and availability. Cameras and real-time analytics signal re-stocks and make sure that items are always available on the shelves. However, unlike Amazon Go, Walmart's IRL has traditional checkout stations and has 50,000 square feet of real retail space, with over 100 employees working in it.

The AI system ensures that there are always shopping carts available for every customer, while it drives down costs by performing janitorial and inventory functions in the store, allowing the firm to save money for further employees.

2.4 AI applications in Healthcare

The use of Artificial Intelligence in the healthcare industry is booming around the world. Healthcare has always been a difficult sector to work in due to the high fixed costs that medicine requires, leaving companies no choice but to invest heavily in the area.
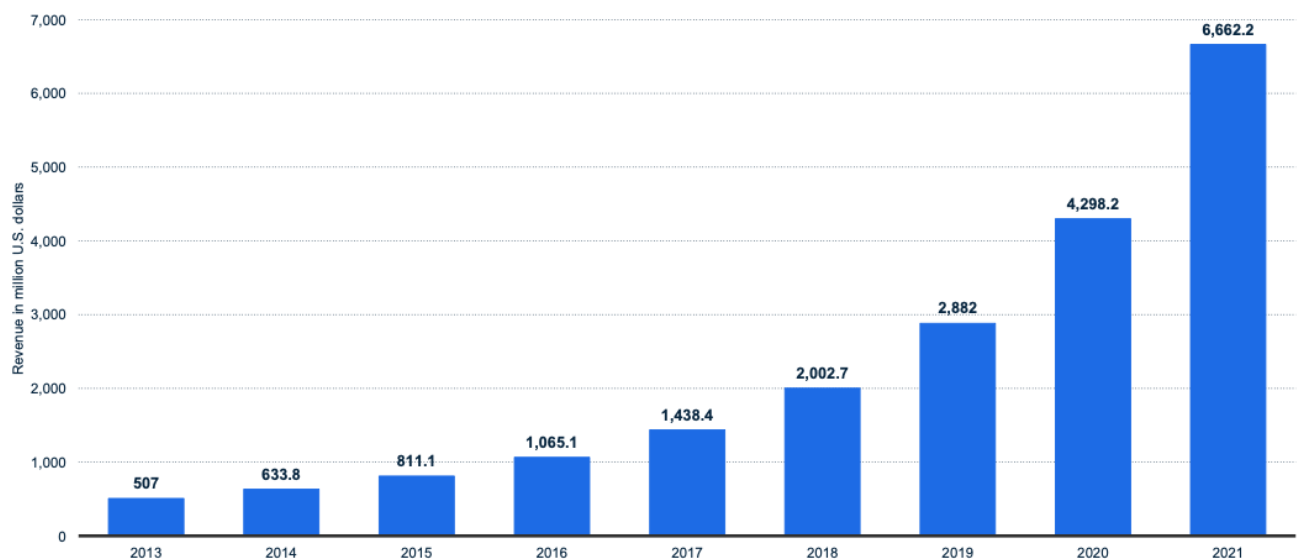
AI will contribute to revolutionize the healthcare industry in different aspects, enhancing innovation and transforming how care is delivered.

The use of Artificial Intelligence and Machine Learning in the healthcare industry involves controversial opinions. On the one hand, if there is absolutely no doubt that healthcare represents the industry in which AI can express the greatest potential, on the other there are still some people arguing that such personal information should not be delivered so easily, and several privacy concerns have raised.

Nevertheless, as the debate continues, investment in AI is increasing at a fast pace across the world, particularly in North America, Europe and Asia.

Figure 2.5 – IP Pragmatics; Frost & Sullivan. (December 2018). Revenue from artificial intelligence systems in healthcare worldwide from 2013 to 2021 (in million U.S. dollars). In Statista – The Statistic Portal. Released by Arne Holst.

Healthcare data includes static data from patients records and diagnostic images, as well as dynamic data from beside monitors or remote patient-monitoring. With AI analytics, this data can be processed to obtain meaningful insights that could play a crucial role in saving people's lives, analyzing disease patterns and tracking new possible outbreaks.

The data generated in the health care industry increases by 48 percent every year. The amount produced in 2020 alone could exceed 2.3 zettabytes, or 2.3 trillion gigabytes, which is approximately the amount of data necessary to watch 262 million years straight of HD movies. [11]

AI will finally contribute to drive down costs, as well as the time that the medical staff has to spend with patients to assess their conditions and provide them with a correct treatment.

AI is being useful in the early diagnosis of several diseases, especially the most difficult to cure, such as cancer. This, in turn, enables doctors to better manage the disease and provide the person with a personalized path to follow in the next stages.

Robots have been a support tool for doctors for a long time now, assisting them during surgeries or in rehabilitation tasks and now they are going to take the next step in healthcare. In addition, robots give people the possibility to live independently for a longer time, reducing the need for hospitalizations and care homes while speeding their life expectancy.

There are major opportunities to increase efficiency in seven areas across the health care value chain:

- *Remote prevention and care*: wearables and other AI appliances can aid patients and provide them with real time information and treatment outside the hospital or the doctor's surgery;

- *Diagnostics support*: hidden pathologies and medical conditions can be diagnosed earlier thanks to artificial intelligence techniques, which can enhance prevention and care of the patients. A better outcome and a reduction in costs may be achieved;

- *Treatment pathways and support:* individual treatments can be carried on by means of AI tools;

- *Drug discovery and development:* investment in R&D is increasing across biopharma enterprises and AI is accelerating the process;

- *Operation:* automation can speed bureaucracy and paperwork;

- *Marketing and sales:* AI can boost efficiency of sales and help to satisfy target markets;

- *Support functions:* the successful combination of AI and robotics is critical for the automation of conventional tasks and processes.

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[11] Inovalon. (2020). The New York Times.

Despite what many people could think, the use of AI in healthcare is not meant to replace workers, but to allow them to be more efficient, maximize their skills and, ultimately, spend more time with their patients.

Moreover, AI is causing shifts in health care value pools. In particular, three primary categories will be affected: biopharma, providers and payers.

In the light of this, we can immediately realize the impact that AI, machine learning and deep learning can have on people's health.

AI is enabling doctors to access a broader set of data, leading to better outcomes and faster diagnoses. Many pathologies are diagnosed years before than what it used to be, giving doctors more time to deal with the disease and cure the patient in a more effective way.

Alzheimer's disease

Researchers at the UCSF Department of Radiology and Biomedical Imaging have used this technology to analyze brain screens. The result was that the model can diagnose Alzheimer's disease up to six years before a clinical diagnosis. One of these tests showed a 92% accuracy rate and another was 98%.

According to Dr. Jae Ho Sohn, who authored the study, it was the perfect representation of how deep learning networks are applied, since it was possible to notice very subtle but diffuse elements, which are unusual to observe in such cases. Slight changes are more difficult to notice and humans struggle with the issue of finding slow, global mutations.

The real issue of such pathology is that usually symptoms only appear when neurons have already died and the damage is already irreversible. This application could lead to a real improvement both in the detection and the treatment of the pathology.

AI in New Drug Discovery

AI-enabled solutions have already delivered new candidate therapeutics and have done it in a shorter amount of time than usual. This is because AI reduces timelines for drug discovery and improves the agility of the research process while increasing the accuracy of predictions. Furthermore, the efficacy and safety of drugs are improving on a consistent basis.

A Deloitte's 2019 report shows that, in the past few years, the number of AI companies focused on discovering new drugs using innovative approaches to discover and preclinical testing has increased rapidly.

In the past three years, most biopharma companies have been adopting a variety of strategies to actively integrate AI into the discovery process, such as establishing their own dedicated teams by hiring AI experts and data analysts, investing in start-ups, and creating collaborations with tech giants and/or research centers.

Drug discovery deals with data concerning the 3D structure of small molecules and their corresponding peculiarities. In this way it is possible to properly individuate the target and address its specificity very accurately, as it happens for face recognition. Likewise, the same reasoning may be applied in order to prevent toxicity and undesirable effects.

AI leads to a better identification of new diseases but in shorter time and more accurately. In particular, AI algorithms are able to tailor approaches for a complete understanding of pathological cellular and molecular mechanisms.

The three pharma companies that lead the way in drug discovery with AI are respectively Pfizer, Takeda, and Sanofi, but also other companies are putting much effort in this sense, trying to compete with AI.

With this regard, most of these companies are partners with high-tech giants. For instance, Pfizer promoted a drug discovery partnership with IBM Watson to accelerate processes in immune oncology. Another important player in the pharma industry is Novartis that, in September 2019, announced a multiyear alliance with Microsoft, which will use data and AI to transform how medicines are discovered, developed and commercialized.

Around the world, North America (namely the US, Canada, and Mexico) accounts for the largest share of AI in the drug discovery market. These countries have been early adopters of AI in this market, especially the US, which is the global leader.

2.5 Smart Cities

The smart city concept is dynamic and evolves over time, which makes it very interesting to analyze. The word "smart", in fact, can have multiple meanings, especially when it is applied to cities. In general, smart cities generate sustainable economic growth and high quality of life by offering public and private services to their citizens. The concept is built around the ability to offer such services so that they are perfectly suited to the needs of the individuals. In particular, the implementation of disruptive technologies, such as AI and IoT is a fundamental characteristic of smart cities.

Smart cities are the result of pooling together the best technological instruments from all sectors of society to enhance people's lives. Most of these technologies are already disruptive on their own, but they are way more powerful when they do not operate in a vacuum, but together, jointly. And the key ingredient to make a city smart is, once again, data.

Smart cities nowadays generate oceans of data, in all their complexity and scope. Local governments use the data to adapt to changing circumstances: seeking insights is particularly useful to wisely allocate resources and plan ahead to better organize the future events. Furthermore, thanks to the increasing information, both individuals and firms can make better decisions while improving the city's overall performance and shape.

As cities get smarter, they become more livable and more responsive to the needs of the citizens. Today we are just starting to realize what technology is able to do in the urban environment. Rapid progress has paved the way for a disruptive innovation in several sectors, such as connectivity, the Internet of Things, smartphone penetration, analytics, and machine learning.

Another definition of smart city might be a city connecting physical infrastructures with ICT infrastructures to leverage the city's overall intelligence. As a matter of fact, through a massive deployment of IoT, smart cities integrate into urban infrastructure forming a "digital skin" around them. All the technologies involved have a tremendous effect on urban life and its day-to-day interconnections. In fact, the key point about these applications on smart cities is that they are deeply interrelated. This means that none of them could have been an innovation without the reciprocal application of the other. The range of novel applications is constantly expanding, together with their capabilities, which are becoming more and more accurate.

In order to be able to apply these concepts, a city needs to analyze enormous amounts of data. The ability to generate and capture massive volumes of information is crucial for a correct deployment of the applications in complex infrastructure systems, which are often crowded with millions of people. Thus, the technology base is made up of three major elements, which support both the present applications and the ones that will be added in the future.

Firstly, cities need a layer of sensors and devices throughout the physical environment. One of the most popular technologies is the Internet of Things (IoT), which involves a system of interrelated devices that store, manage and transfer data over a network without any kind of interaction.

The definition of the Internet of things has been changing continuously due to the convergence of multiple technologies and the introduction of artificial intelligence, machine learning and real-time analytics.

Secondly, cities need robust communication networks. In the past few decades, information and communication technologies (ICT) have provided society with a vast range of new communication capabilities. For example, people can communicate instantaneously with others in different countries using technologies such as instant messaging or videoconferencing. Social networking websites like Facebook and Instagram allow users from all over the world to remain in contact and communicate on a regular basis. As a matter of fact, the situation we have been through due to coronavirus is a clear example of exploitation of communication improvements. During the period of quarantine, people all over the world communicated and worked through ICT technologies leading so towards a "smarter" world.

Modern information and communication technologies have revolutionized the way in which people can communicate one another across the world as if they were living next door. For this reason, ICT concerns how modern communication technologies can affect society.

In addition, ICT encloses the internet-enabled domain and the mobile one powered through wireless networks. It encompasses old technologies as well, which are commonly used together ICT elements such as robotics and AI. These old technologies include radio, landline telephones, and television broadcast. Even though the list of ICT components can be considered rather exhaustive, it continues to grow. Some elements have been in vogue for quite a long time, like personal computers, while others are rather new, such as smartphones and even robots, which are quite recent.

Free public Wi-Fi connection is another fundamental aspect for residents and tourists in a town. Smartphones are actually essential for this purpose because they serve as mobile sensors while people move along the city. As the individuals go around the streets, phones produce real-time data (such as location and other features) and are the most popular way for users to interact with their apps.

Thirdly, open data portals stimulate innovation in several ways. Local governments are provided with valuable data in their infrastructures, environment and public records. In fact, a number of cities all over the world share publicly the information collected, such as reports of school performances, results of health inspections in restaurants, and statistics about the reported criminal activities in a neighborhood.

Big data and data science are so closely interconnected that are even reported to be one thing. However, there are some differences to remark. Although data science is concerned with data processing, data planning, and data interpretation, big data has a different role. Indeed, big data is mainly used to gain information and insights which are useful to improve the decision-making process and the strategic business activities.

Data is the fuel to train AI algorithms and improves the responsiveness of the overall system, but data must be expressed in a readable and accessible way. Therefore, unstructured data need to be converted into a standard format that is meant to be easily accessible to external developers, so that they can analyze, share, and manage the information. AI algorithms improve as the quality of data increases, enabling the system to perform more sophisticated functions while minimizing the possibilities for mistakes. As a matter of fact, accuracy, flexibility, and agility are fundamental qualities that organizations need to develop if they wish to reach a new ecosystem of growth. Thanks to analytics, companies can process large amounts of data, which can be turned into relevant insights to boost profits. In fact, companies that are able to handle great quantities of data sustain market competitiveness, mitigate risk and enhance customer satisfaction.

Big Data has the absolute potential to change the way in which business is conducted and discoveries are made. Furthermore, the most striking thing is that it is likely to change how people live and behave, including governments, institutions and organizations.

In addition, data visualization is a fundamental function that data scientists need to execute. For example, an effective visualization of the information is essential for turning data into real intelligence. Data visualization has been implemented by industry leaders, such as Facebook, Google, Twitter, and Amazon to handle complex sets of data. The outcome in terms of ROI, profitability, and stability has been highly positive.

Data is a crucial enabler to gain a competitive advantage. It represents a strategic, impersonal asset that organizations can leverage to outperform rivals in the market. Gaining insights into stakeholders, industry features, and trends can create new opportunities for businesses, which can be quickly monetized. As a matter of fact, there are several industrial sectors where big data analytics are paying off. It is the case of the communications sector, but a large number of growing industries are experiencing the benefits of such technological improvement.

To accomplish the objectives of smart cities, technologies are fundamental. These objectives, such as reduce resource input, high quality of life and a mostly digital solution are the basis to the called "digital shadow" of a city.

AI can help to develop the Smart city concept, especially in these areas: mobility, public safety, waste, traffic management and energy.

Chapter 3. Ethics and Artificial Intelligence

3.1 The Ethics of Artificial Intelligence

Ethics is a challenging topic that requires organizations to constantly update their strategy, their way of conducting business, and their approach to consumers. It is a controversial subject that has no unique definition, and there are a number of different views about the concept of right and wrong, which makes it very hard to turn such principles into standard algorithms.

The adoption of artificial intelligence in several areas has raised controversial opinions and experts have deployed different approaches to AI over time.

Everyone agrees on the fact that AI can benefit a given business or society, but the limits on how that should be achieved are much more difficult to define, since the concept of AI involves privacy issues, data management and the ethical problems that may go along with them. In particular this is definitely true when an AI system is endowed with autonomous decision-making without any human involvement in the process. To what extent is a machine entitled to make decisions so that people can benefit from them? And to what extent is it safe to release personal information so that a business can collect data and improve the quality of its services?

The impact on the stakeholders of a business will be discussed, including customers and policymakers, which are crucial when talking about data security and privacy concerns. The main purpose of AI ethics is to optimize the benefits while minimizing the risks linked to the adverse outcomes for all stakeholders and promote the well-being of the society.

Even though more data enable a given system to produce a better outcome, the answer might be different according to the type of decision that needs to be made, as it entails a number of potential drawbacks with respect to gender, race, status, sexual orientation or religion.

Nowadays, AI plays an active role in every major business, but, at the same time, it is still very hard to formulate the ethical principles and regulations that are necessary to build a technology that is always ethical and beneficial at the same time.

AI has already shown how powerful it is and how deeply it can affect areas such as business, robotics and healthcare, promising huge improvements for the social development and the economic growth of humanity and society as a whole. Likewise, the future of work as we know it and the replacement of old-fashioned jobs are two of the areas that will be redefined by the development of ethical AI. It will improve healthcare by offering faster and more accurate diagnosis, it will boost the productive

system and increase the security of our devices and it will create new jobs and new opportunities. However, the risk is that such technological advancement could outpace the ethical framework in which AI is supposed to operate.

Experts are starting to realize the importance of incorporating ethical AI in their business plan to build consumer trust and increase brand reputation, since ethical issues can damage the business and have a negative impact on stakeholders.

What is certain is that AI does not operate in a vacuum. First of all, any AI model is supposed to make decisions according to the regulatory requirements of the specific environment involved in order not to display any bias. Anyway, it must be clarified that what is generally defined as legal is not necessarily ethical, too. Therefore, the issue can be much more complex to analyze.

At the European level, some laws about AI have already been established and, in addition to the legislation applicable horizontally, there are also several laws applicable to each specific sector. On April 8 2019 the European Commission presented the "Communication on Building Trust in Human-Centric Artificial Intelligence", where the Commission describes the key elements necessary to develop what is called "trustworthy AI", which should be *lawful* (respecting all applicable laws and regulations), *ethical* (respecting ethical principles and values) and *robust*, both from a technical perspective while taking into account its social environment. These key principles are the following:

- Human agency and oversight: AI should enable people to make better predictions and take more informed decisions, based on their fundamental rights;
- Technical robustness and safety: the technological systems must ensure the safety of consumers by protecting their rights, minimizing harm and increasing reliability;
- Privacy and data governance: high-quality data should be managed in a respectful way in order not only to protect consumers but also to legitimize access to personal information, guaranteeing full data protection;
- Transparency: data must be transparent in the sense that stakeholders need information to be clear for them to understand the dynamics of the decision-making process and the function of AI algorithms;
- Diversity, non-discrimination and fairness: unfair discrimination must be avoided so as to eliminate prejudice and any negative implication while fostering diversity;
- Societal and environmental well-being: sustainability is a crucial point for AI to be beneficial to the future generations, preserving the environment and minimizing societal harm;

- Accountability: decisions must be derivable from the algorithms used in the process, including the moral values and the norms put in place. It deals with a guiding action and the explanation function.

These key principles are the starting point for developers to elaborate their AI systems.[12]

The truth is that there is no unique understanding of the concept of ethics, which makes it very hard for engineers to program algorithms that can be considered ethical by every society in the world and that, most of all can maximize the utility of every business.

People require algorithms to be transparent and understandable, as well as intuitive for users and business teams, but one of the problems encountered with the transparency of AI is the black-box nature of the deep learning networks, which most of the time prevents them from being easily interpretable.

The increasing demand for greater transparency has taken hold in recent years, but if on the one hand, transparency can increase fairness and alleviate discrimination issues, on the other it can raise new risks. Being more vulnerable to attacks, hackers could take advantage of the situation thanks to release of additional information. This so called "transparency paradox" is represented by the trade-off between the benefits that could be achieved by generating more information and the risks that could appear for the same reason. To address this paradox, organizations need to pay attention to how information is collected and shared throughout the enterprise so as to guarantee that data is protected. The development of technologies and applications based on artificial intelligence systems will reshape our future, but the rights and the needs of the people should be at the center of the project and should be always respected.

In the last months we have changed our habits and our approach to life in general and technology has had an overwhelming impact. Likewise, artificial intelligence has played an active role in redefining our days and has contributed to reshape our concept of work, school and life as a whole.
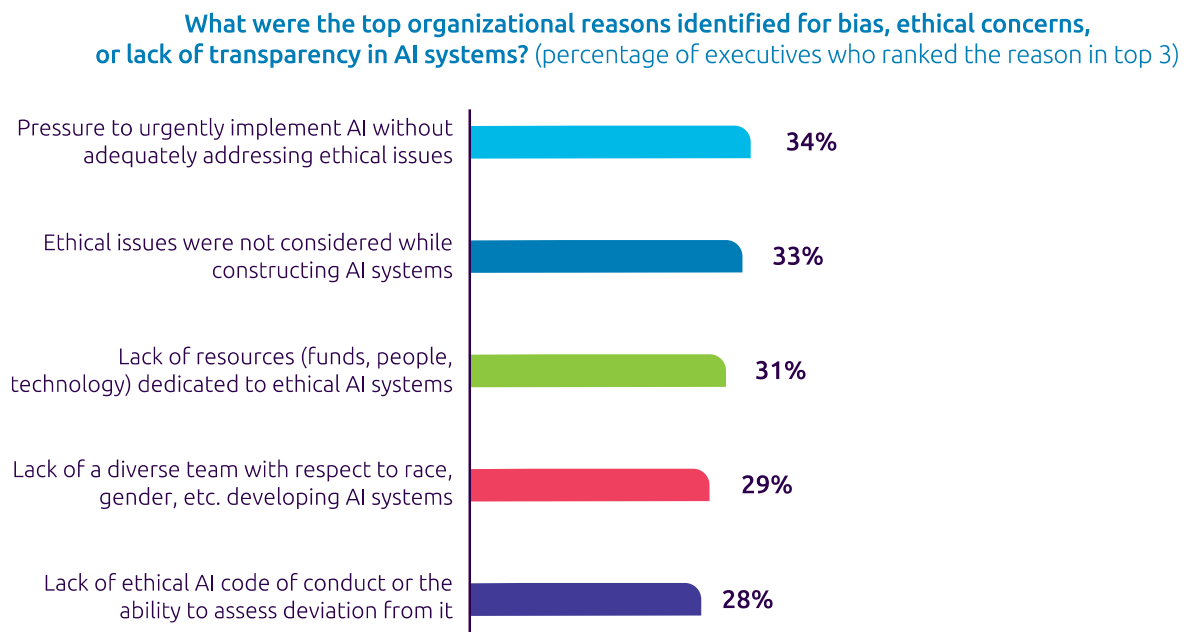
3.2 The main issues behind AI ethics

In the last years most organizations have encountered ethical issues associated to their AI systems and experts are starting to take action to minimize such issues. These ethical issues go beyond the mere storage of personal data, since they involve the manipulation of behavior, privacy and

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[12] European Commission: Ethics guidelines for trustworthy AI. Report/Study 8 April 2019.

surveillance concerns, job loss and income inequality, the possible bias in decision systems, discrimination issues, and the automation dilemma.

Most of the time many of these problems are the result of a mistake in the system and are simply unintentional. In such cases the data is not perfectly aligned with the system and does not take into account all the environmental factors it should incorporate, so it is not something that comes from the people who create the algorithm. For this reason, it is very complicated to find the right balance that is needed to eliminate any kind of bias.

According to a survey carried on by Capgemini Research Institute, the main reason why companies are not able to properly deploy ethical AI is because they are too hasty. In fact, the pressure to implement AI is fueling ethical issues and is causing companies to fail AI.

What were the top organizational reasons identified for bias, ethical concerns, or lack of transparency in AI systems? (percentage of executives who ranked the reason in top 3)

Pressure to urgently implement AI without adequately addressing ethical issues — **34%**

Ethical issues were not considered while constructing AI systems — **33%**

Lack of resources (funds, people, technology) dedicated to ethical AI systems — **31%**

Lack of a diverse team with respect to race, gender, etc. developing AI systems — **29%**

Lack of ethical AI code of conduct or the ability to assess deviation from it — **28%**

Source: Capgemini Research Institute, Ethics in AI executive survey, N = 1,580 executives, 510 organizations.

Figure 3.1 – Capgemini Research Institute. (2019). Ethics in AI executive survey, N = 1580 executives, 510 organizations.

In particular, the graph above shows that *34% of executives identified pressure to urgently implement AI without adequately addressing ethical issues as one of the top organizational reasons for bias, ethical concerns, or lack of transparency in AI systems*.[13]

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[13] Capgemini Research Institute. (2019). Why addressing ethical questions in AI will benefit organizations.

The urge to gain a first-mover advantage in the market or to collect benefits in a short time might have been responsible for a bad implementation of ethical AI. As we always said, AI is costly and it takes time to harvest the benefits, since they are not immediate and require acting proactively on a long-term basis. Like any other technological innovation, AI involves a crucial trade-off between innovation and efficiency.

Among consumers there has been some level of disappointment, too. In particular according to the same Capgemini survey, almost half of consumers (47%) have experienced AI-related ethical issues, such as processing of personal data for no-agreed purposes or without consent, biased/unclear recommendations from AI-based systems and reliance on machine-led decisions without disclosure. These are some of the most common reasons why consumers do not put 100% of their trust in AI systems, but there is still great margin for improvement. Ethical AI can increase brand reputation and awareness and most of all, can gain consumer trust. In order to do so, executives should make sure that AI systems are not opaque, and the outcome should be transparent and clear both to the end user and the programmer of the system. In addition to that, high-quality data is required for a successful outcome because if data is biased then also the algorithm that uses that data will reproduce that bias. Experts must pay attention to the rights of the consumers, as well as to the quality of the data used and must eliminate any form of discrimination or systematic error within the system.

3.3 Automation: will machines steal our jobs?

Addressing the topic of automation involves taking into account the benefits that AI and Robotics will have on productivity and economic growth, while managing the threats on unemployment and job loss. Self-driving cars, smart virtual assistants like Alexa and Siri (respectively from Amazon and Apple), healthcare robots and customer services chatbots are just some of the ultimate representations of automation.

Like any kind of technological revolution, automation will have a strong impact on work and on the working class, especially in the next decade, since it could cause some level of labor displacement. However, what will happen in the long run, instead, is more difficult to predict and the answer could vary according to the specific industrial sector or the kind of occupation covered.
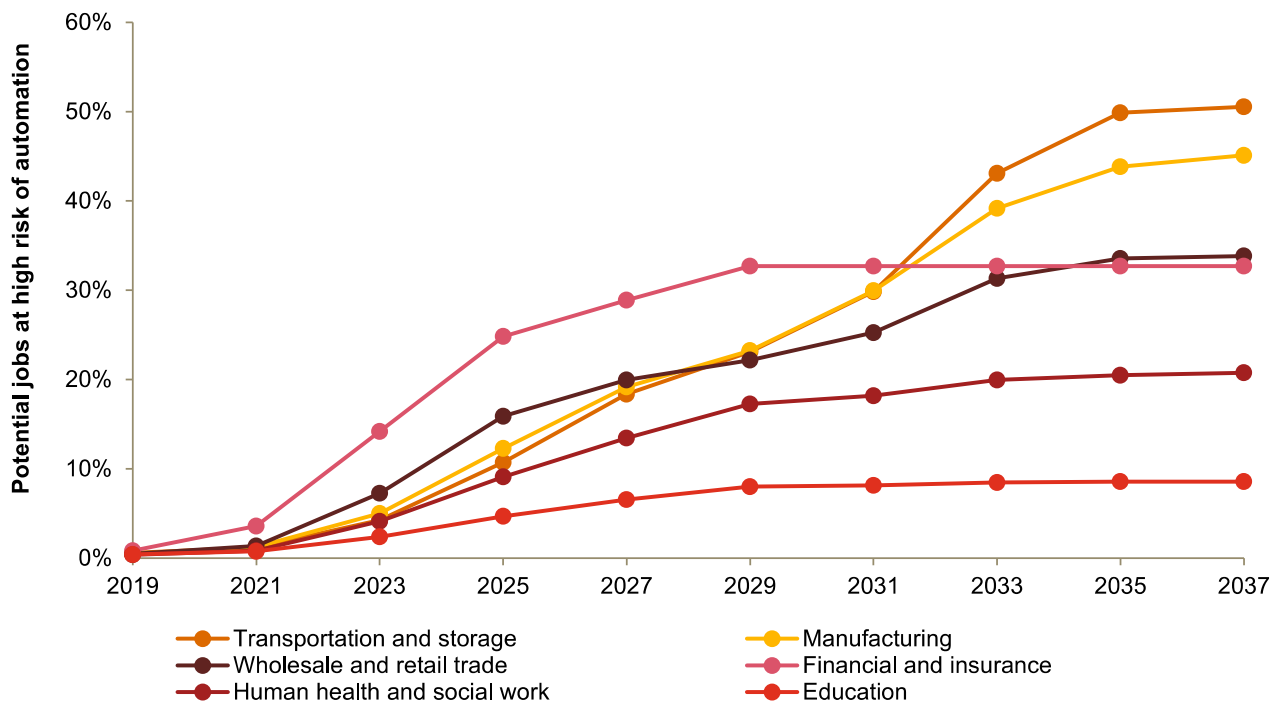
That being said, there are several factors that will determine how countries will react to automation, starting from occupation, sector and wage rates. In addition, it is hard to predict exactly what will be the final effect on workers, but there is no doubt that some industrial sectors are certainly more exposed to the risk of automation than others. Nevertheless, this does not mean that those sectors will

necessarily experience structural unemployment for a long period of time, but they will be deeply affected in the sense that workers will need to develop new skills and abilities and adapt to a new concept of work and, eventually, new forms of jobs will be created. Acquiring new skills will be of crucial importance for their own well-being.

The key point is that work will change in the sense that it will evolve, and workers will need to adapt.

Occupations involving a great amount of physical work in what are defined as "predicable environments", such as production workers and building and grounds cleaners, as well as office supports (like clerks and administrative assistants), will probably be the most exposed to the automation shift and will face significant job displacement. On the other hand, professionals like doctors, healthcare providers, lawyers, and engineers are much less likely to face such displacement, and the automation will have a minimum impact on their professions.

According to a 2019 PricewaterhouseCoopers report on automation, the process of automation will affect industries differently over time. For instance, the transportation and storage sector initially shows small potential for job automation, but it will reach a peak in the following decades, as the automation process takes hold in the market, reaching a 50% potential of automation by 2037. At that point, in fact, autonomous vehicles and driverless cars are meant to become adopted worldwide. Likewise, the manufacturing sector, whose occupations are expected to reach over 40% of job automation, for example with the 3D printing process. The Financial and insurance sector, instead, is likely to follow the opposite pattern, having a great potential for job automation in the first decade up to almost 30% in 2027, while lowering the risk in the years to come. Conversely, the education sector shows a low risk of job substitution, given the empathic abilities of teachers and professors, which are difficult to reproduce for a machine or a robot.
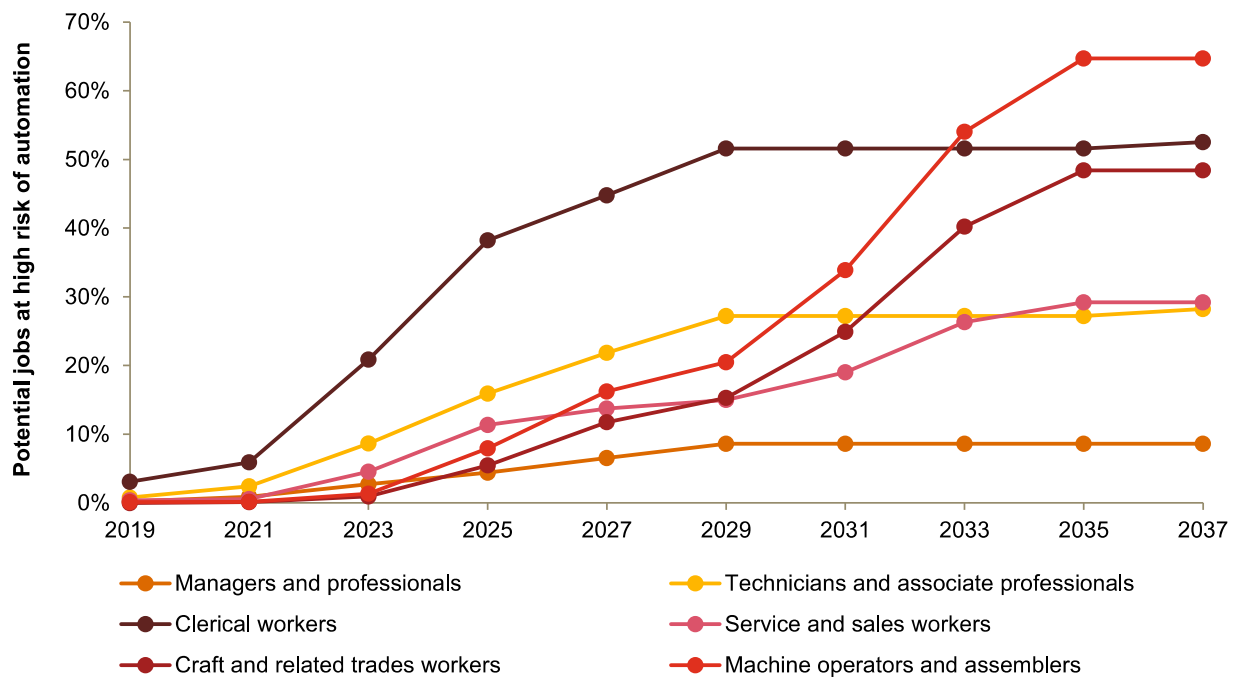
Source: PIAAC data, PwC analysis

Figure 3.2 –PricewaterhouseCoopers. (2018). Potential impact of job automation over time across industry sectors. From the report "Will robots really steal our jobs? An international analysis of the potential long-term impact of automation".

Of course, this will depend on the pace of adoption of automation techniques, which will vary according to the social and economic situation of the country.

Going into more depth into the types of occupation that will be affected by the automation process, we can apply the same reasoning as before. The impact on occupations will shift over the years, as with the industrial sectors. Human capabilities, social interaction and emphatical skills are hard for robots to reproduce, since they are typical of the human nature, as well as logical reasoning and creativity. In other words, what is easy for humans could be very difficult to accomplish for robots, which are better at collecting data, analyzing facts, and reproducing static behavior. Therefore, the jobs requiring emphatical skills are less likely to be displaced.

The category which is expected to experience the highest level of job automation is the one containing machine operators and assemblers, which will reach over 60% of automation by 2037, whereas the least exposed are managers and professionals. The main differences lie on the type of tasks to be accomplished and on the abilities required.

Figure 3.3 – PricewaterhouseCoopers. (2018). Potential impact of job automation over time across occupational categories. From the report "Will robots really steal our jobs? An international analysis of the potential long-term impact of automation".

The effects of automation are likely to increase productivity and improve well-being. Some people argue that in the future they will be offset by the creation of new jobs and, in turn, of new demand. The final effect of automation is likely to increase the economic welfare of the countries. Increasing investments in infrastructure and technology, boosting productivity and improving the quality of the services offered through a more skilled workforce will generate a positive outcome in the market, which will offset the initial unemployment that might arise.

Now it is important to establish whether it is ethical to pursue the interests of the society as a whole rather than the individuals. What it is most likely to happen is that workers will adapt to new circumstances and this means that new jobs will be created. Therefore, the society will benefit from this shift and workers will become more skilled in several sectors.

It is not a choice between the interests of the society and the interests of the individuals. Work will be reshaped by the technological cycle, as it always happens. Consequently, workers will adapt, and everyone will be better off.

3.4 Artificial Intelligence during the COVID-19 Pandemic

In our recent times, communities from all over the world have been struggling with the ongoing pandemic of the coronavirus disease, which was named COVID-19.

The pandemic is with no doubt the greatest challenge that nations have faced since World War II.

This pathology caused and is currently causing thousands of deaths in every part of the world, with substantial consequences on the economic welfare of the nations. The outbreak was first noticed in Wuhan, in the province of Hubei, China, in December 2019. China was the first country to experience the disease and soon after that decided to go into lockdown to contain the virus. Likewise, Italy was the second country to face the consequences of the novel coronavirus, and on March 11 the World Health Organization (WHO) recognized it as a pandemic.

From that moment on, all the countries all over the world started to face the disease and adopted a complete closure of all the economic and commercial activities, while people were not allowed to go around in the streets anymore and obliged to stay home and apply quarantine measures.

Despite the strong security measures, the virus has kept spreading at an exponential pace, and experts state that the virus will be part of our lives for much more time than expected.

The extreme difficulties are represented by the impossibility to restrict the spread and the consequent contagious of the infection among people.

Most people, in fact, are forced to work in high risk conditions, especially the medical staff, which is probably the category that is exposed the most to the disease.

AI is making it possible to overcome the extreme difficulties by providing further opportunities for scientists and doctors in several ways.

- *Diagnosis and Treatment*

The Campus Bio-Medico University (Rome), which is under the sanitary network of Region Lazio, has been the first center in Europe to adopt an AI system for the early detection of pneumonia related to Covid-19.

This can be really considered a breakthrough in the system, since it has allowed to diagnose the novel coronavirus in 20 seconds, with a reliability rate of 98,5 percent.

The AI structure has already been tested on a number of anonymous patients by the radiologists of the Campus, led by the director of the UOC of Diagnosis for Images Professor Carlo Cosimo Quattrocchi and the director of the Imaging Center Professor Bruno Beomonte Zobel.

The application is totally based on artificial intelligence and not only is capable of giving an immediate answer on the type of pneumonia affecting the patient (which can be viral for Covid-19 or

deriving from other bacteria), but is also capable of calculating the volume of pulmonary compression in cubic cm, providing information about eventual progress or worsening of the medical condition of the patient.

The importance behind this is not represented by the diagnosis itself, but by the positive consequences that it could create: more people can be diagnosed faster, speeding bureaucracy to move towards an optimized turnover inside hospitals.

But this is just one example to how AI can contribute to this issue, since it is already playing an important role in other areas, such as the prediction of the spread of the Covid-19, which is at the hearth of the problem.

The cost of the pandemic in terms of lives and economic damages will be catastrophic. There is a profound sense of uncertainty behind this issue, including the estimates of the final impact of the disease.

The real problem is represented by the lack of data and information about the virus itself, which is new to everyone and it is hard to predict the potential repercussions even for virologists and the medical staff.

AI, in the form of Machine learning (ML), Natural Language Processing (NLP) and Computer Vision, is mitigating the uncertainties behind the virus with regards to what is actually feasible in terms of data privacy and public health concerns. There are, in fact, structural limitations to the adoption of AI in the sanitary systems, especially when there are people's lives at stake.

- *Cure and Vaccine*

Even before the COVID-19 outbreak, artificial intelligence was considered to be potentially crucial for new drug discovery. Right now, the most important researchers from all over the world are working hard to find a vaccine for this novel coronavirus. Finding a vaccine and testing it on humans requires time, but experts agree that it is the only way this tragedy can end, once for all. It is very likely that we will be struggling with this virus until a proper vaccine is found. The hope is that AI can speed the process.

In January, Google's DeepMind introduced AlphaFold, a cutting-edge system that predicts the 3D structure of a protein-based on its genetic sequence and, in March, the system managed to analyze the structure of the proteins of the virus.

Now experts are examining fragments of SARS-CoV-2 to determine how they might apply to COVID-19 vaccines.

- *Social Control*

Right now, Artificial Intelligence is being adopted by a number of nations to help tracking and predicting how the COVID-19 disease is going to spread over time and space. This kind of information is crucial for health authorities to plan and manage the effects of the pandemic.

To better assess the magnitude of these effects, nations need to visualize their position on the epidemiological curve and decide the actions to be undertaken to succeed in flattening the curve and decreasing the number of infections.

Furthermore, AI has been quite widely used in support of mass surveillance policies in China and in every part of the world, where devices have been used to measure temperature and recognize individuals. Facial recognition has been largely used to pinpoint the temperature levels of individuals and assess the presence or not of a surgical mask on their face.

In the last weeks, an AI app has been proposed by some governments, like Italy, to monitor the movements of the people in the country and prevent a further spread of the disease. There has been a number of complaints about the possible privacy concerns that might arise, and the debate is still going on as we speak.

On the other hand, the global crisis caused the demand for medical equipment to increase exponentially and the market was not able to react due to the shortage in the supply of these products. For this reason, several companies from other industrial sectors shifted their production towards this kind of equipment, which is necessary for people when facing such situation.

This is when the combination of AI and 3D printing can achieve a breakthrough in the area.

To fight the COVID-19 pandemic, the Italian Department of Health recommended the development of the Immuni App, which was launched on June 1, 2020 in 4 regions (Abruzzo, Liguria, Marche and Puglia) and then extended all over the country on June 15, 2020.

The app was developed by the start-up Bending Spoons, it is free, and can be downloaded from any digital store. Now it counts more than 4 million users and is currently taking hold.

Immuni aims at tracking people who test positive to the coronavirus in order to prevent the further spread of the virus. This is accomplished through Bluetooth technology that is able to retrace all the people who have been near the infected person, meaning within an approximately one-meter distance. The app sends an alert notification to all the users who have been recently in contact with the infected individual (in a restaurant, in a pub, or in a shop) and then sends a list of recommendations to those people describing how to behave in that situation. In this way, the app could manage to self-isolate the infected people to avoid infecting others.

The whole process is based on the willingness of the people, since the app is not mandatory.

The people choose to download the app in the first place and then to follow the instructions, such as to contact the healthcare provider in case of possible infection.

The main issue concerns the privacy of the users. Most people feared that their personal information could be manipulated or used for other purposes and were concerned about the protection of their identities. To avoid such issues, Immuni protects users by guaranteeing their anonymity and the ethical treatment of their personal data. When someone receives a notification of alert, the identity of the infected person is kept anonymous. All the data are managed by the Ministry of Health and by other public entities and are prevented from being shared with other third parties. The app does not register the user's first name, phone number or date of birth and does not track his movements. Hence users have nothing to be afraid of.

However, in order to be highly effective, the app should be downloaded by the majority of the population, otherwise its benefits might be rather limited. In fact, the more people download the app the higher the number of users that could be readily notified.

During a meeting in the Senate on April 29, the Minister for Technological Innovation Paola Pisano described the five fundamental points that the App must respect:

1. The whole tracking system must be managed by one or more public bodies;
2. The code must be open and it must be possible for every entity to study or revise it;
3. The data must be sufficiently anonymous to prevent the identification of the person concerned
4. The app is not compulsory and every citizen can freely choose whether to use it or not
5. Once the aim of the app is accomplished, all the data, apart from the ones gathered anonymously, will be deleted.

AI is playing a key supporting role in the fight against the COVID-19 pandemic, including diagnosis, social control, contact tracing, manufacturing, social distancing, and even workplace safety. However, every application requires a specific type of data and involves some challenges, such as respecting privacy issues and minimizing the uncertainty behind the data. This is due to the fact that the data developed during training may not be as accurate as it should be when it comes to realistic applications and may contain a bias, leading to unreliable results. In the table below there is a summary of the existing and potential AI applications to deal with the COVID-19 pandemic, some of which are already being used successfully.

TABLE III
SUMMARY OF EXISTING AND POTENTIAL AI APPLICATIONS TO DEAL WITH THE COVID-19 PANDEMIC, DATA NEEDED, CHALLENGES NEED TO BE
ADDRESSED, AND AI METHODS CAN BE USED

Applications	Types of Data	Challenges	Related	AI Methods
Screen and triage patients, identify effective personalized medicines and treatments, risk evaluation, survival prediction, healthcare and medical resource planning.	Clinical symptoms, routine laboratory tests, blood exams, electronic health records, heart rate, respiratory rate, data observed from previous patients, e.g. clinical information, administered treatments, patients' case history.	- Challenging to collect physiological characteristics and therapeutic outcomes of patients. - Low-quality data would make biased and inaccurate predictions. - Uncertainty of AI models' outcomes. - Privacy and confidentiality issues.	[87]–[93]	Machine learning methods, e.g. SVM, MLP, fuzzy system, ElasticNet regression [94], decision tree, random forest, nonparametric Gaussian process [58], and deep learning techniques such as LSTM [45] and other recurrent networks.
Predict number of infected cases, infection rate and spreading trend.	Time series case data, population density, demographic data.	- Insufficient time series data, leading to unreliable results. - Complex models may not be more reliable than simple models [95].	[26], [96], [97]	
COVID-19 early diagnosis using medical images.	Radiology images, e.g. chest X-ray and CT scans.	- Imbalanced datasets due to insufficient COVID-19 medical image data. - Long training time and unable to explain the results. - Generalisation problem and vulnerable to false negatives.	[98]–[116] and works in Table I.	Deep learning CNN-based models, e.g. AlexNet [3], GoogLeNet [4], VGG network [5], ResNet [6], DenseNet [23], ResNeXt [24], ZFNet [117], and AI-based computer vision camera systems, facial recognition systems.
Scan crowds for people with high temperature, and monitor people for social distancing and mask-wearing or during lockdown.	Infrared camera images, thermal scans.	- Cannot measure inner-body temperature and a proportion of patients are asymptomatic, leading to imprecise results. - Privacy invasion issues.	[118]–[120]	
Analyse viral genomes, create evolutionary (phylogenetic) tree, find virus origin, track physiological and genetic changes, predict protein secondary and tertiary structures.	Viral genome and protein sequence data	- Computational expenses are huge for aligning a large dataset of genomic or proteomic sequences. - Deep learning models take long training time, especially for large dataset, and are normally unexplainable.	[55], [74], DeepMind's AlphaFold [48], [49]	- Sequence alignment, e.g. dynamic programming, heuristic and probabilistic methods. - Clustering algorithms, e.g. hierarchical clustering, k-means, DBSCAN [72] and supervised deep learning.
Discover vaccine and drug bio-chemical compounds and candidates, and optimize clinical trials.	Viral genome and protein sequences, transcriptome data, drug-target interactions, protein-protein interactions, crystal structure of protein, co-crystalized ligands, homology model of proteins, and clinical data.	- Dealing with big genomic and proteomic data. - Results need to be verified with experimental studies. - It can take long time for a promising candidate to become a viable treatment.	[50], [121]–[129]	Heuristic algorithm, graph theory, combinatorics, and machine learning such as adversarial autoencoders [50], multitask CNN [121], GAN [50], [122], deep reinforcement learning [50], [123], [124].
Making drones and robots for disinfection, cleaning, obtaining patients' vital signs, distance treatment, and deliver medication.	Simulation environments and demonstration data for training autonomous agents.	- Safety must be guaranteed at the highest level. - Trust in autonomous systems. - Huge efforts from training agents to implementing them to real machines.	[130]–[133]	Deep learning, computer vision, optimization and control, transfer learning, deep reinforcement learning [134], learning from demonstrations.
Track and predict economic recovery via, e.g. detection of solar panel installations, counting cars in parking lots.	Satellite images, GPS data (e.g. daily anonymized data from mobile phone users to count the number of commuters in cities).	- Difficult to obtain satellite data in some regions. - Noise in satellite images. - Anonymized mobile phone data security.	[135], [136]	Deep learning, e.g. autoencoder models for feature extraction and dimensionality reduction, and CNN-based models for object detection.

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Applications	Types of Data	Challenges	Related	AI Methods
Real-time spread tracking, surveillance, early warning and alerts for particular geographical locations, like the global Zika virus spread model BlueDot [137].	Anonymized location data from cellphones, flight itinerary data, ecological data, animal and plant disease networks, temperature profiles, foreign-language news reports, public announcements, and population distribution data, e.g. LandScan datasets [138].	- Insufficient data in some regions of the world, leading to skewed results. - Inaccurate predictions may lead to mass hysteria in public health. - Privacy issues to ensure cellphone data remain anonymous.	BlueDot [139], Metabiota Epidemic Tracker [140], HealthMap [141]	Deep learning and NLP tools, e.g. NLTK [61], ELMo [62], ULMFiT [63], Transformer [64], Google's BERT [65], Transformer-XL [66], XLNet [67], ERNIE [68], T5 [69], BPT [70] and OpenAI's GPT-2 [71] for various NLP tasks such as text mining, automatic summarization, relationship extraction, text classification, sentiment analysis, named entity recognition, topic segmentation, machine translation, question and answering.
Understand communities' responses to intervention strategies, e.g. physical distancing or lockdown, to aid public policy makers and detect problems such as mental health.	News outlets, forums, healthcare reports, travel data, and social media posts in multiple languages across the world.	- Social media data and news reports may be low-quality, multidimensional, and highly unstructured. - Issues related to language translation. - Data cannot be collected from populations with limited internet access.	[142]–[144]	
Mining text to obtain knowledge about COVID-19 transmission modes, incubation, risk factors, non-pharmaceutical interventions, medical care, virus genetics, origin, and evolution.	Text data on COVID-19 virus such as scholarly articles in CORD-19 dataset [81].	- Dealing with inaccurate and ambiguous information in the text data. - Large volume of data from heterogeneous sources. - Excessive amount of data make difficult to extract important pieces of information.	[145]–[147]	
Mining text to discover candidates for vaccines, antiviral drugs, therapeutics, and drug repurposing through searching for elements similar to COVID-19 virus.	Text data about treatment effectiveness, therapeutics and vaccines on scholarly articles, e.g. CORD-19 dataset [81] and libraries of drug compounds.	- Need to involve medical experts' knowledge. - Typographical errors in text data need to be rectified carefully.	[129], [148]–[152]	
Making chatbots to consult patients and communities, and combat misinformation (fake news) about COVID-19.	Medical expert guidelines and information.	- Unable to deal with unsaved query. - Require a large amount of data and information from medical experts. - Users are uncomfortable with chatbots being machines. - Irregularities in language expression such as accents and mistakes.	[153]–[161]	

Figure 3.4 - Nguyen, T. T. (2020). Summary of existing and potential AI applications to deal with the COVID-19 pandemic, data needed, challenges need to be addressed, and AI methods can be used. From Artificial intelligence in the Battle against Coronavirus (COVID-19): a Survey and Future Research Directions.

As it has been always argued during this thesis, what AI requires in order to be highly effective is high-quality data, which is the lifeblood of AI. This is the main reason why it is hard for experts to estimate with great accuracy the proportions of a possible new outbreak and the consequences that might go along with it. Furthermore, the use of data requires a considerable involvement of ethics, norms and regulations, especially when we talk about healthcare.

Conclusion

Even though Artificial Intelligence is not something new, it has gained popularity in the last years thanks to the development of supporting technologies and, in particular, Big Data.

Artificial Intelligence, typically defined as the ability to reproduce human cognitive functions, is part of our lives and affects our actions every day, although we do not realize that.

This analysis aimed at showing that AI-firms are able to earn higher profit margins with respect to traditional operating models, enhancing economic growth and creating a new workforce. However, several challenges need to be addressed. The key to fully benefit from the use of AI at scale is to create a successful combination between human and machine capabilities. This can only be accomplished through the creation of a corporate culture that embraces change and promotes innovation.

Retail, e-commerce, and healthcare are three of the industrial sectors in which AI is playing a crucial role, as it is shown by the analysis concerning the Amazon case and other companies. AI and Machine Learning techniques are extensively adopted also in other areas, such as manufacturing, finance, and marketing.

AI is costly and it takes time to see the benefits behind its adoption. Enterprises must implement a proactive strategy on a long-term basis and collect high-quality data. At the same time, the people behind AI algorithms should be truly committed to moral and ethical values, otherwise ethical issues may arise. Transparency can mitigate fairness and discrimination issues, as well as privacy concerns. A bad implementation of ethical principles can damage the business image and stakeholders may be negatively affected.

Another crucial concept concerning AI is automation. People might fear the possibility of job displacement in the short-term, but the truth is that the effects of automation are likely to increase productivity and improve well-being. In this way, the positive outcome in the market will offset the initial unemployment that might arise, workers will develop new skills and society as a whole will be better off.

AI is not meant to replace workers or to substitute human minds. Conversely, it is meant to achieve higher efficiency and optimize business processes. It is meant to improve people's well-being, paying more attention to their needs and proving them with better services.

Challenges and opportunities are two sides of the same coin. We have been struggling with the COVID-19 pandemic, which has revolutionized our habits and our way of living. However, it must

be said that during this period, we have experienced a new concept of work and life in general, in which AI has played an active role in redefining our days. AI instruments are making it possible to overcome the extreme difficulties by limiting the spread of the virus and controlling the disease. In addition, AI has provided new ways of conceiving work and school, through the adoption of smart-working activities and distance learning.

In conclusion, Artificial Intelligence is a powerful tool that creates new value for people. It is already part of our lives, but there are major opportunities for improvement and adoption. The AI market is growing rapidly, and the trend will continue in the future.

AI is about to reshape our world.

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