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## **The Impact of Artificial Intelligence in Banking**

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## **Abstract**

The following thesis will focus on the general topic of Artificial Intelligence (AI). The main purpose of this work is to investigate how generally AI is being implemented and developed in modern times. As banks process almost all individuals' purchases, these can analyse those and know their customers better to deliver them a powerful experience. This research aims to assess the current impact of AI in banking and the consequences of it, and how banks benefit now and then. Banks will use AI to deliver fully personalized experiences and to perform their operations with more efficiency.

## **Keywords**

Artificial Intelligence, Banking, Automation, FinTech

## **1. Introduction**

### **1.1 Background**

The Covid-19 pandemic crisis has supercharged the adoption of Artificial Intelligence (AI). According to a PWC study, 52% of companies accelerated their AI adoption plan due to the pandemic. Of this 52%, 86% have claimed that AI will become a “mainstream technology” in their company in 2021 (PWC 2020). The trend does not seem to be just a trend of the pandemic but a trend that will continue through the 2020s. A survey by The AI Journal has demonstrated that leaders are confident that AI will play a significant role in the future. 74% predict that AI will bring more efficiency to business processes, create new business models (55%), and help create new products and services (The AI Journal 2020). The increasing adoption of AI means it is being used in very distinct ways by the different industries to perform various tasks and achieve very distinct goals. As such, to continue to move toward its crucial to continue to revolutionize and update its processes. An excellent way to do so is by gaining insight into different industries that have personalized and created processes to maximize AI and learn from it. Usually, these techniques imply gains in productivity in production processes and daily-routine tasks since these can be automated by machines or fully digitalized. However, it is vital to provide a definition and an understanding of what AI is, what it might achieve and the main risks and benefits it brings across several industries and sectors clear to the general population. Usually, when people think about AI, a significant portion still thinks that it is a tool to eradicate jobs, increase revenues and collect data to breach privacy. According to a study performed by the Oxford Commission on AI & Good Governance, 47% of North Americans and 43% of Europeans think that including AI in our lives will mostly be harmful. If we explore the answers by profession groups, construction and manufacturing workers are the most worried – 42% think it will be mostly harmful –, while agricultural workers are the least worried ones – 28% think it will be harmful, while 38% believe it will mostly help (Oxford Internet Institute 2020).

## **1.2 Motivation and Purpose**

The main goal of this is how the different industries could learn from each other and what patterns are visible throughout the diverse industries.

The rest of the paper is organized as follows: In chapter two, the authors analyse the concept of Artificial Intelligence, its history, and its acceptance. The third chapter comprises an overview of the different fields of artificial intelligence. In the next chapter, the authors examine the different benefits and risks of AI, both in a general overview and a sector-specific analysis. The fifth chapter is an assessment of investments in AI in an overall and sector-specific evaluation. The sixth chapter will cover a more in-depth dive into specific sectors. Finally, conclusions and comparisons are in the seventh chapter.

## **2. Literature Review**

### **2.1 The concept of Artificial Intelligence**

The definition of AI has been a topic subject to great discussion due to the lack of consensus in defining it. So much so that no singular definition of the field is universally accepted. While numerous definitions of AI have emerged over the last few decades, John McCarthy provided the following in 2004, “It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence. Still, AI does not have to confine itself to methods that are biologically observable” (McCarthy 2007). However, a distinct and more comprehensive definition was proposed by Nils Nilsson in 2010, “Artificial intelligence is that activity devoted to making machines intelligent, and intelligence is that quality that enables an entity to function appropriately and with foresight in its environment” (Stanford 2016). The main limitation in defining AI as merely making machines intelligent is that it does not clarify what AI is and what exactly is an intelligent machine. Thus, Britannica brought forth another definition along these lines, “The ability of a digital computer or computer-controlled robot to perform tasks

commonly associated with intelligent beings. The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience” (Britannica 2021). Simply put, AI is the intelligence that is manifested by machines. These are programmed to mimic human actions in order to, later on, be able to execute activities that are commonly correlated with human minds, including problem-solving, learning, and performing physical tasks (Advani 2021).

Strong artificial intelligence (AI), also referred to as general AI or artificial general intelligence (AGI), is a theoretical kind of AI that describes a particular approach to AI development. Strong AI aspires to mimic human functions including reasoning, planning, and problem-solving. Simply said, Strong AI strives to develop intelligent machines that are indistinguishable from human mind (IBM 2020). Weak AI, also known as narrow AI, focuses on a single activity, such as answering questions or playing chess depending on user input. It can only perform one sort of activity at a time, while Strong AI can handle a wide range of tasks. To ensure accuracy, Narrow AI relies on human intervention to specify the parameters of its learning algorithms and to provide appropriate training data and eventually educate itself to tackle new problems. On the other hand, while it accelerates it is the growth phase, strong AI does not require human input, eventually, it will teach itself how to solve new issues (IBM 2020).

## **2.2 The history of AI – Main marks in history**

The idea of a “Machine that thinks” goes way back, being first mentioned in ancient Greece, but gained particular importance after the birth of computing. Specifically, when Alan Turing published *Computing Machinery and Intelligence* and posed the question “Can machines think?”. Six years later, John McCarthy coined the term “Artificial Intelligence” for the first time. Since then, AI has come a long way, from different programs like Deep Blue, Watson and AlphaGo defeating champions in Chess, Jeopardy and more recently GO, a Chinese game, with

great complexity. Neural networks have also significantly evolved, starting in 1967 with Frank Rosenblatt and its Mark 1 Perceptron, the first computer-based neural network learned through trial and error. More recently, Baidu's Minwa supercomputer identifies and categorizes images with much higher efficiency than humans. AI has also come far in terms of practicality; in the past, it was pure fiction. Nowadays, it is embedded in daily life, with most people carrying an artificial assistant in their pocket. Likewise, AI is present in most, if not every, industry, being used as a tool to reach multiple goals in a wide variety of scenarios, including control management, personalization, customer interaction, decision making, and much more.

### **2.3 AI Acceptance**

The importance of AI is rising in all parts of society. It is regarded as a source of competition and innovation as it proposes targeted solutions in different areas. However, despite many people using AI every day, it is evident that not everyone accepts or agrees with it (Arnold 2021).

On the one hand, recent studies show that the support towards AI is more significant among the wealthy, educated, and those who have more experience dealing with technology. On the other hand, an analysis by the OECD reveals that subgroups are more vulnerable and less enthusiastic towards AI and workplace automation. These include people from developed countries with lower levels of education, low incomes, and individuals whose jobs could easily become automated. Hence, people who struggle to pay their bills regularly are more hostile towards AI and robots than those who never experienced difficulties. Moreover, other analyses further mention that men are, in general terms, more accepting of AI than women, which could be due to the fact that women have shown greater distrust in technology than men (Zhang and Dafoe 2019).

On a different note, Pegasystems, a leader in customer engagement software, carried a global study to assess consumer views on AI. The data unveiled that consumers have mixed feelings

towards AI. While most are eager to welcome AI and recognize a promising future ahead, others fear AI and still favour human communication over a machine when given the option. Another aspect that is open to discussion is that consumers believe AI falls short of fulfilling their expectations, mainly due to the lack of understanding of the concept. Thus, there is room for companies to take advantage of this uncertainty and align their approach with their consumers' preferences (Pega 2019).

The acceptance of artificial intelligence also differs from country to country. In Asia, the perception of AI is usually favourable, around two-thirds or more in most Asian countries. For example, Singapore (72 percent), South Korea (69 percent), India (67 percent), Taiwan (66 percent), and Japan (65 percent) believe AI has benefited society (World Economic Forum 2020). However, most of the other continents and regions polled do not agree that AI has benefited society. Countries such as France, the UK, and the US are predominantly negative towards AI's impact on society. On the other hand, Sweden and Spain are two of the few countries outside of Asia-Pacific where a majority of people (60 percent) think AI is a good thing (World Economic Forum 2020).

Consumers and corporate leaders have different concerns about AI. In the next five years, AI will significantly impact the way companies do business, according to 85% of CEOs. However, there are differing viewpoints on how much AI may be trusted. Over three-quarters of CEOs believe AI is "positive for society," but even more say that AI-based choices must be explainable to be trusted (84 percent) (World Economic Forum 2019). A survey from the Economist assessed whether executives thought AI could live up to its hype or not. A fifth of the respondents claimed that AI was "just hype and no substance", whereas 36% stated they thought it helpful but that there is hype in this technology. On the other hand, 36% thought AI would live up to its promises (The Economist 2020). The pandemic changed a little bit this perception. Since the pandemic, 50% of respondents stated they have a more favourable view

of AI. Of these respondents, the most confident industries that AI would help them during the pandemic were mining, manufacturing, and technology. The least confident ones were travel and tourism, consumer, and retail (The Economist 2020). The adoption rate is also a good way of measuring how accepting AI is in varied industries. A study from O'Reilly shows that Computers, electronics, and technology, unsurprisingly, topped the list with 17% of respondents. Financial services (15%), healthcare (9%), and education (8%) are the industries that are using AI the most. In the pharmaceutical and chemical industries, we find minimal AI utilization (2%). Similarly, only 2% of responders are from the automotive industry, even though AI is critical to emerging goods such as autonomous vehicles. Finally, the energy industry accounted for 3% of the respondents, while public utilities accounted for 1% (O'Reilly 2021).

### **3. The main fields of Artificial Intelligence**

The objective of this section is to present and explain the main fields that exist related to AI. These are the main tools used to deliver tasks once performed by human intelligence such as learning, reasoning, solving problems, identifying, and understanding languages and perceive specific situations or environments (Future Today Institute 2021). The fields found are based on the interest put on by several studies and books, such as (Nilsson, The Quest for Artificial Intelligence 2009), (Minsky 1960), and (Russell e Norvig 1995), and include Machine Learning (ML), Robotics, Natural Language Processing (NLP), Computer Vision and Expert Systems.

#### **3.1 Machine Learning (ML)**

ML is a field of AI where algorithms learn from huge amounts of data without human intervention to improve the accuracy in making predictions and pattern detection (Nilsson 1998). According to (Russell e Norvig 1995), inside these ML algorithms we can still make the distinction between three: supervised, unsupervised and reinforcement learning. Supervised learning is a subset of ML that uses labelled datasets (e.g. if we are trying to predict the age of

someone, age is our label), meaning that the label is the variable we want to predict – if both inputs and outputs can be seen, that is supervised learning. The most common models are Regressions (to predict outputs that are continuous variables, such as the height of someone) and Classification (the outputs are discrete variables, and sometimes “yes” or “no”, like when we’re trying to prevent the churn rate of a website). Unsupervised learning uses unlabelled datasets, meaning that we have no output variable to predict. The most common algorithms are Clustering (group data based on similarity) and Dimensionality Reduction (simplify data by reducing the number of features). Finally, reinforcement learning algorithms deal with no data and must solve problems. Instead of dealing with data, it deals with an environment, where correct decisions give rewards and wrong decisions give punishments. One known use case is chess – the algorithm will try random moves and receive rewards or punishments for them and then will learn how to reach the terminal state: *check!* (Russell e Norvig 1995).

### **3.2 Robotics**

Robotics develop artificial agents that are designed to perform human tasks and interact in the physical world environment (Russell e Norvig 1995). It literally studies robots (designs, production, and operation), machines that can be used to perform human tasks alone or supervised by someone. They can be used in manufacturing automation, exploration of the sea, hazardous waste inspection, surgeries, environment monitoring (e.g., drones), home robotics (e.g., autonomous vacuum cleaners), among others. According to Medium, regarding the main fields inside this subject, the focus is on Operator Interfaces, Mobility or Locomotion, Manipulators and Effectors, Programming, and Sensing and Perception. As for the first one, an operator interface is a vehicle through which the user of the robot and the robot itself communicate, meaning that it is the platform through which a human gives instruction to a robot. Robots need to move from a place to another to complete their job, and that’s why mobility and locomotion are a field of great interest (for instance, drones use propellers and

other systems to move, and those need to be developed). These machines also need to grab, transform, and move objects like they had a human hand (one of the most common applications is in the auto-industry), and that's why researchers are putting effort in manipulators and effectors. Programming is important since it is the language used by the user to communicate with the robot (and this is where ML might help, since robots can learn to avoid mistakes). Finally, sensors are fundamental to collect data to inform the robot about the environment around it (Medium 2020).

### **3.3 Natural Language Processing (NLP)**

NLP gives computers the ability to extract data from written and spoken words, allowing for tasks such as translation and speech recognition (Nilsson 2009). Combined, computational linguistics, statistics and deep learning models can perform NLP tasks. It translates pieces of text from a language to another, allows machines to answer to voice commands (e.g., *Hey Siri*), serves as the motor to chatbots as they identify the text written, process and understand it and powers GPS systems to talk, for example. Concluding, the main fields of interest are text processing, speech recognition and speech synthesis – and most of them rely on ML algorithms to perform (IBM 2020).

### **3.4 Computer Vision**

Computer Vision deals with allowing machines to collect information through vision, analysing images or videos to make predictions and pattern recognition (Nilsson 2009). We need to distinguish this concept from image processing – the last one aims to create an image from an existing one, while computer vision aims at understanding what is happening (Machine Learning Mastery 2019). When there is a surveillance system, it is not uncommon to have two cameras capturing some common zones – that is actually a good way to interpret distances between objects and help in making decisions. The main tasks and fields computer vision is exploring are optimal character recognition (e.g., when someone gets a speed ticket, the camera

automatically reads the plate number), machine inspection (e.g., scan the status of the outside of a plane to check if it is ready to fly again), retail (recognition of products for an automatic checkout, like the one used in the Amazon Go shops), warehouse logistics (development of package deliveries in an autonomous way), medical imaging, self-driving vehicles (by analysing the environment, the car adapts the speed and the turns), 3D model building (from information collected by drones and planes), motion capture, surveillance (analysing the traffic, drones in the sea, etc) and fingerprint recognition and biometrics (Szeliski 2021).

### 3.5 Expert Systems

Expert Systems are computer systems simulating complex human decision-making by explaining the reasoning behind it. These are being integrated with databases to do recognition and decision-making like humans, with the final objective of creating knowledge discovery with the help of data-mining processes and end up with an intelligent database. It brings visible advantages, such as an increased availability (since these systems are not specific to a single computer), reduced costs per user (as a fixed cost, if the number of users increases, the average cost decreases), consistency (if a human is tired will treat some problems with greater difficulty, while an expert system is always ready), multiple expertise converted into one machine, explanation of the reasoning behind the decisions done, quick responses and emotion-free opinions (Jackson 1998).

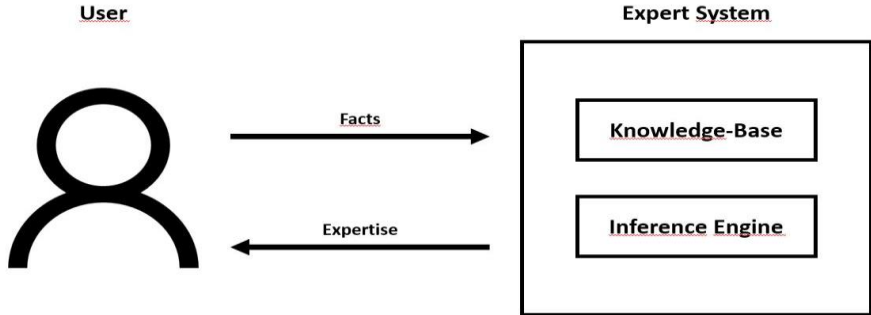


Figure 1: : An Expert System, based on (Jackson 1998)

Most of the times these fields are not exclusive and require connections to achieve better results. For example, Deep Learning (DL), a subset from ML that trains techniques such as Artificial Neural Networks (ANN), techniques are used in NLP algorithms, since these are built to tackle and understand the temporal nature of language (Jurafsky e Martin 2000). ANN are a set of networks composed by non-linear elements (Nilsson 1998) and are compared to real neural networks since they adjust the weights of connections with new inputs just like the human brain connections between neurons change with more information, and both learn to make more accurate decisions (Russell e Norvig 1995). These DL algorithms are used in Computer Vision (Goodfellow, Bengio e Courville 2016) like the recognition of sound waves from the vibrations they reproduce in objects seen in video (Davis et al. 2014) Also, DL algorithms are used for Robotics. (Punjani e Abbeel 2016) used a DL algorithm to try to represent the dynamics from a helicopter through a network model, and the model outperformed the baselines by large.

From the relations stated above and the studies observed, we can check that specially DL is used to complement several other fields of AI. One of the best-known cases of how these Neural Networks are present in our lives is to look at how easy it is to communicate with an iPhone just by saying “Hey Siri” – a practical application of DL in speech recognition and NLP. The holder of the iPhone says “Hey Siri”, there is a Deep Neural Network (DNN) that converts the acoustic pattern of the voice into a probability distribution, and then temporal integration to calculate a confidence score to check whether “Hey Siri” was said or not (Apple Machine Learning Research 2017). If instead of talking to Siri, the holder just wants to unlock its iPhone through face detection, another DNN – and here we have DL helping Computer Vision.

#### **4. The benefits and risks of AI**

##### **4.1 General / Ethics of AI**

The use of AI involves several benefits and is accompanied by numerous risks at the same time. Davenport and Ronanki (2018) are approaching AI through the business lenses and describe it

as a cognitive technology which benefits three major business needs: automating business processes, gaining insights through data analysis, and engaging with customers and employees.

The most common type is the automation of digital and physical processes, which are generally easy and cost-effective to implement and usually bring a quick and high return on investment. It is especially useful for automating back-office work like transferring data and updating customer records or extracting information from multiple document types using natural language processing. These kinds of business-processes are often outsourced offshore and can be automated, which results in reduced costs without a loss of employees (Davenport and Ronanki 2018). Routine operational activities, such as maintenance systems, accounting and information inquiry tasks are performed much better and faster by AI systems than by humans (Lee and Yoon 2021).

The second most frequent use of AI is in the field of data analytics with the help of algorithms for pattern detection and interpretation in order to gain business relevant insights. With the help of data analytics, companies can predict what a customer is likely to buy, identify credit fraud in real time or automate personalized targeting of digital ads. Such tasks are often beyond human ability and therefore do not pose a significant threat to human jobs (Davenport and Ronanki 2018).

Cognitive engagement represents another main benefit of AI, which is used less frequently by companies compared to automating business processes and gaining insight through data analysis. This category includes the deployment of intelligent agents that offer customer service at any time. It is also used within companies on internal sites for answering employee's questions regarding HR or IT related topics. In addition, it comes to use in health treatment recommendation systems that help to customize care plans under consideration of individual patients' health status and previous treatments (Davenport and Ronanki 2018).

Also, companies can stay ahead of the competition by transforming products and services. In R&D heavy sectors, AI can accelerate the product innovation and discovery process through accessing new value-adding areas (Møller et al. 2018). A widespread concern in society is that AI will replace a majority of jobs performed by humans. A health app called Noom provides customized support to their clients in order to help them attain their health goals. From 2017 to 2019 the number of Noom's employees rose from 77 to 1100. That significant increase shows that AI can not only help to improve products and services, but also that AI can facilitate the creation of many new jobs (Lee and Yoon 2021).

The numerous benefits of AI are accompanied by a lot of risks and proves this technology to be a double-edged sword. Used responsibly, it can improve our lives in many ways. Yet even AI generates business value and consumer benefit, it is also giving rise to umpteen risks and unwanted consequences which negatively affect individuals, organizations and society (Cheatham et al. 2019).

On an individual level, AI can be harmful in economical, psychological as well as physical ways. The underlying black box character is the root cause for unexplained actions the algorithm might perform, like unreasonably banning a client's credit card or unjustifiably accusing a person of a crime (Diakopoulos 2016; Dourish 2016). Further, physical threats arise through autonomous-vehicle malfunction, overreliance on inadequate equipment predictive-maintenance or the misdiagnose of medical conditions by machine learning models (Cheatham et al. 2019).

Another risk of AI is the unequal distribution of power. On the one side, governments and organizations have access to useful tools and resources like client data and highly developed technology. On the other side is the majority of society which does not have access to these powerful tools (Someh et al. 2016). 2016, Facebook's CEO Mark Zuckerberg was accused of

abusing his power when algorithms of the social media platform censored the photograph of the “napalm girl”, a historic picture of a naked girl which is iconic for the Vietnam war. Another example is the use of automated bots on Twitter, Facebook, and Reddit during the 2016 U.S. presidential election and UK European Union Referendum, which interacted with users and promoted certain content and viewpoints (Mittelstadt 2016).

A further risk of AI are possible discriminatory effects. The below figure shows the results of a study about the COMPAS machine learning algorithm by *ProPublica* which is one of the most prominent cases about discrimination through AI. The algorithm is used by judicial systems in the U.S and supports judges in their decision making through assessing the risks of former prisoners to become delinquent again when released from prison. Figure 2 shows the error rates of the COMPAS algorithm and its discriminatory bearing. African Americans are almost twice as likely as white people to be labelled a higher risk but actually did not re-offend, whereas white people are labelled a lower risk yet did re-offend way more often than African Americans (Yapo und Weiss 2018).

	White	African American
Labeled Higher Risk, But Didn't Re-Offend	23.5%	44.9%
Labeled Lower Risk, Yet Did Re-Offend	47.7%	28.0%

Figure 2 - Disproportionate error rates, from Ethical Implications Of Bias In Machine Learning (Yapo und Weiß 2018)

The case of the COMPAS algorithm is just one of many examples of discriminatory effects induced by AI. The origin of the problem is the underlying bias due to bad data and lack of

inclusivity. If a ML model is trained solely on data of a specific group, it is obvious that the result is less diverse and might neglect certain groups with fewer occurrences in the training data (Yapo und Weiß 2018).

Further, the close relationship of big data and AI implies concerns about privacy and data protection. The processing of personal data by algorithms proves to threaten individuals' privacy, especially when it comes to analysing and predicting socio-economic aspects of individuals. A survey revealed that two thirds of Europeans expressed concerns regarding data security (Payne et al., 2015) and also the majority of Americans are worried about the use of their personal data by companies and governmental institutions (Auxier et al., 2019).

In the following, we will see that the benefits and risks discussed so far do not apply for a particular sector only but can be found in most common industries in which AI comes into use.

## **4.2. Benefits and risks per sector**

### **4.2.1. Banking and Finance**

Financial institutions are trying to change the way they interact with their clients or customers. One of the main benefits AI brought to these sectors is the way they interact with their clients through insights and advice, giving them a personalized experience to their needs and objectives (Tink, Tink's guide to Improving digital banking through personalised insights 2021). This contributes to a better customer or user experience, increasing the probability of having a client staying for a longer time and recommending the services to its peers – more than 50% of bank clients think personalized experiences are drivers to trust the institutions. These technological mechanisms can speed up decision making when it comes to allow or not for a loan – risk assessment mechanisms and underwriting processes get faster with machine learning algorithms since these can manage multiple data sources at the same time. This means a faster loan generation, and clients get happier in a shorter time (Deloitte US 2021). Also, regulatory

reporting becomes easier, clearer, and more accurate with the help of AI. There is no need for a lot of manual interventions like mappings and reviews, regulatory changes will be easier to address due to the speed machines take in adapting and the quality of the reports increases (PwC 2020). Finally, fraud detection and anti-money laundering mechanisms are developed through machine learning techniques as well, preventing financial institutions to process illegal transactions and detect potential crimes. These are used to detect fraud patterns and do real-time analysis of movements to perform risk-monitoring (McKinsey 2020).

Regarding the risks, the amount of data collected by these institutions to create tailor-made products can make them breach privacy laws – if they hold the data for longer and for more purposes than the ones held in the contracts with the customers (Atkins e Luck 2021). Also, because of the huge amount of data collected, banks and other financial institutions get more prone to be victims of cyberattacks and information leaks. These algorithms are designed to help in decision making, and if they are not well done, final outcomes might be biased or not accurate. Financial institutions need to be careful when dealing with these outcomes and make sure that they are transparent, accurate and aligned with the culture and objectives of the firm (Deloitte, AI and risk management: Innovating with confidence 2018). If we say that personalized banking experiences might be a driver for increasing customer loyalty, the fact that there are fewer human interactions can be a reason to decrease that same metric, and therefore institutions need to look carefully at this – a few years ago, changing from one banking institution to another would be a high-cost process, while today, with the developments seen in AI, this is way easier and with increasing customer demand for good services these financial institutions will need to step up their game and provide reasons for their customers to stay around longer (Forbes 2019).

#### **4.2.2 Healthcare**

“An ounce of prevention is worth a pound of cure.”, said Benjamin Franklin, one of the Founding Fathers of the United States of America, back in 1735.

One of the main benefits AI and robotics are giving to this sector is early detection of diseases such as cancer. The American Cancer Society says 12.1 million mammograms are done per year in that country, and the usage of AI is making review and translation 30 times faster and with an accuracy of 99% (Wired 2016). Diagnosis is also easier with the help of these algorithms. 80% of health data comes unstructured, making it hard to read, meaning that only 20% of the data is easy to read by computers (such as numerical data or records pre-organized by humans) (Healthcare Data Institute 2015). IBM developed Watson for Health, and this tool processes and stores far more data than any human, allowing for a quicker and more accurate diagnosis. Also, predictive analytics tools can inform and support clinical decisions and help doctors to prioritise tasks on the treatment (PwC 2017). AI may also benefit the treatment process for patients and help doctors manage the treatment plans – example of AiCure, a platform that helps people with long-term conditions to comply with their medications by visually recognizing the face of the patient, the medications it is taking and to confirm the success of the ingestion. It also offers virtual assistance to the patients and assesses the progression of conditions over time (Vasishtha 2018). Finally, it accelerates the process of putting medical solutions in the market. The California Biomedical Research Association estimates that it takes 12 years for a drug to go from discovery to the patients. With the help of AI, these processes last less, and drugs are becoming available in a shorter period (PwC 2017). Just look how fast the Covid-19 vaccine took from discovery to the market – the pandemic started in the end of 2019 in China, reached the rest of the World by the beginning of 2020 and by the 8<sup>th</sup> of December 2020 the first person in the UK received the first shot of the Pfizer

vaccine (BBC 2020). This is one of the great examples showing how can technology help the healthcare industry.

Regarding the risks, one that arises is data bias. Training AI models needs a huge scale of input health data, and if the data used for training does not fit to the population to which the solutions are being applied to. Insufficient or bad quality data can also lead to this bias (Sunarti et al. 2020). According to the same authors, there are privacy issues regarding the hold of sensitive health data – the privacy of the individual is an ethical obligation. Finally, we need look carefully for how these algorithms are built and how accuracy might not be a good indicator of performance. Imagine a program that aims at identifying if a tumour is malign or benign that has an accuracy of 99% – this means that for every 100 predictions, it gets 99 right. What if the one left is a malign tumour that is predicted as benign? The objective of this algorithm is to identify the bad cases, and not the good ones. Therefore, imbalanced classes must be looked after when dealing with these algorithms, and sometimes the technology will not be enough to make decisions.

### **4.2.3 Agriculture**

Similar to the healthcare industry, AI can be used beneficially for the classification and prediction of crop diseases. Based on input parameters about the physical constitution of the plant, diseases can be forecasted and appropriate measures for prevention and recovery taken on an early stage (Tilva et al. 2013). Image processing coupled with an artificial neural network for example helps to classify seedling diseases (Huang 2007) or to detect the percentage of infection in leaves (Sannakki et al. 2011)

Further, rule-based crop management systems provide an interface for general management of all sorts of crops and give advice regarding crop selection, fertilizer application and pest related issues (Bannerjee et al. 2018).

Next to the monitoring of diseases and pests, the handling of harvested crops is also a crucial aspect of agriculture. Bannerjee et al. (2018) refer to various AI powered food monitoring and quality control mechanisms for the storing, drying and grading of harvested crops.

AI is also employed for soil and irrigation management. Rule based expert systems evaluate the design and performance of micro irrigation systems (Brats et al. 1993) or recommend crops depending on land suitability (Sicat et al. 2005). Further, AI is used for estimating soil moisture (Arif et al. 2013) and predicting rainfall using atmospheric inputs (Manek and Singh 2016).

Moreover, AI models are applied to predict crop yield, which is beneficial for estimating crop costs and developing marketing strategies (Bannerjee et al. 2018). Overall, such AI applications provide tremendous support in the decision making for farmers and create value in terms of enhanced crop yield, efficiency and environmental sustainability.

In terms of social sustainability, however, risks due to the dehumanizing character of AI arise. One thinks of driverless machines and other robots that increase the risk replacing traditional farmer jobs. In order to prevent social inequality, the ethics of AI need to be considered similar to other sectors and concerns over data privacy, transparency and unintended consequences of the technology require significant attention (Lakshmi and Corbett 2020).

#### **4.2.4 Retail**

Artificial intelligence has reinvented the retail landscape and is expected to continue that trend.

AI is expected to boost wholesale and retail gross value by \$2.2 Trillion by 2035 (Statista 2021).

The most notable area in which AI has brought great benefits to retail is the customer experience. AI-assisted conversational assistants help customers navigate questions, FAQs, and troubleshooting and redirect them to a human expert when necessary, improving the customer experience by providing on-demand, always-available support while streamlining staffing (Deb Marotta 2020). Chatbots, for example, can respond to many questions at the same time.

This is a lifesaver for companies with overburdened call centres and long wait times. It allows customer service departments to perform more, resulting in a better client experience (Salesforce 2021). Another significant benefit that helped retailers like Amazon become the behemoths today is AI's personalisation to retailing. Personalisation in advertising refers to the use of data or consumer insights to improve an ad's relevance to its intended audience. This can include information like demographics, interests, purchasing intentions, and behaviour patterns. Increasing the relevancy and personalisation of adverts is becoming a primary priority since it significantly improves the user experience and customer retention (IBM 2021). Customers can benefit from artificial intelligence in retail by making product discovery more straightforward as well. Customers may now take a picture of a product they like in the real world and use it to find an online store that sells it (Forbes 2020). Another central area in which AI can create significant benefits for retailers is in making operations more effective. AI can be utilised in forecasting, demand planning, assortment, allocation optimisation, and return optimisation in the supply chain. "When you are shipping billions of packages every year and working with tens of millions of products, you can't do it in that manual process," said Steve Gurney, head of worldwide general merchandise at Amazon Web Services (National Retail Federation 2021). Another area where AI has succeeded is in streamlining warehouse and in-store store operations. From the Amazon robots that help Amazon employees in the packaging process in warehouses to in-store where using AI, shops can easily optimise their space and inventory. Existing consumer preferences, product location, season and weather conditions, expiration dates, and other factors are considered by algorithms to put shelves and products where visitors anticipate to find them intuitively (CHI Software Development 2021).

Nevertheless, AI does bring some disadvantages to the retail industry. For once, privacy violation and data abuse can destroy an organization's reputation and customer trust. More than half of executives express "serious" or "severe" concern about AI's ethical and reputational

hazards in their firm. That means that developing an AI ethical risk program that everyone buys into is required before AI can be deployed at all. For companies that use AI, this must be a priority (Harvard Business Review 2021). Another risk is the replacement of the workforce. According to economists at MIT and Boston University, robots could replace as many as 2 million more employees in manufacturing alone by 2025. “This pandemic has created a very strong incentive to automate the work of human beings,” state Daniel Susskind, a fellow in economics (Time 2020).

#### **4.2.5 Construction**

The adoption of AI in the construction industry is quite low compared with other industries, even though it encompasses many possibilities and potential use cases. AI can be beneficial for optimizing project schedules and for enhancing project planning. In addition, image recognition and classification on work sites can identify and assess unsafe work behaviour. Moreover, analysed sensor-data can be used to understand signals and patterns in order to provide real-time solutions, prioritize preventive maintenance, reduce costs and prevent unplanned downtime (Bianco et al. 2018).

Automation can replace traditional manual observation, which usually tends to be time-consuming and prone to errors. In terms on safety, AI helps to detect and predict potential risks, not only on the construction site, but also when it comes to project management, streamline operations and budget planning. In addition, robots can deal with unsafe operations and replace humans in dangerous work environments (Bolpagni et al. 2021). AI can also amplify the efficiency of the construction execution process through new approaches like process mining. Repetitive routine tasks can be taken over by robots which work continuously without taking a break at almost the same quality and productivity (Pan and Zhang 2021).

Important to mention is the role of Building Information Modelling (BIM), which serves as a “[...] digital backbone to work with AI.” (Pan and Zhang 2021, p.7). Through the collection of

large amounts of data about all aspects of the project, real-time analysis can support to streamline the complex workflow, make processes more efficient and cut costs. In combination with AI techniques, computer vision promotes the understanding of data in images or videos and is used for the inspection and monitoring of complex construction tasks and structural conditions. It provides actionable information about construction safety and can perform automated damage detection which leads to a safer work environment (Pan and Zhang 2021).

On the other side, the advantageous of digitalization are accompanied by the exposure to cybercrime and privacy intrusion with potentially huge economic and financial consequences. Examples of cyber threats in the construction industry include malware, social engineering and phishing. In addition, construction work is often conducted in unsecure environments. Small mistakes by AI can comprise the safety of construction workers and lead to life-threatening accidents. Furthermore, the location of construction sites is often secluded and lack power and internet connectivity. However, AI mostly relies on good internet connectivity and power supply, which poses another threat to the usage of this technology (Abioye et al. 2021).

#### **4.2.6. Hospitality**

The hospitality industry is expected to reach USD 44.38 billion by 2026, and there is an urgent need to revolutionize it. The most promising approach is to invest more in AI technologies in the industry and therefore improve its customer service and experience, which they rely upon heavily. The hospitality industry has adopted digital technology long ago due to the significant amount of data generated. For hospitality specifically, AI's primary purpose is to explore and analyse guest data, aid in decision-making, and manage guests' complaints. Nevertheless, the industry could take more advantage of the use of AI and incorporate it into different areas within hospitality (Roy 2021).

The main benefit for the hospitality industry in adopting AI is that, by doing so, it can offer services that are somewhat more accurate, timely and efficient, when in comparison to relying

solely on people's capabilities. Along with this is AI's ability to provide customers with better experiences aligned with their interests. This is feasible as AI streamlines processes, analyses them, and collects valuable data from different sources, therefore improving its recommendations. Another substantial benefit AI brings for hospitality is its ability to enhance customer profiles based on previous guests' history, preferences, and satisfaction, consequently generating a more loyal customer base (Qualetics 2020). Nonetheless, AI is also beneficial in the sense that it aids those working in the industry. Germany-based Model One has been testing a robot nicknamed Sepp to answer simple questions and deliver basic information to customers. IBM Watson was the mastermind behind Sepp's creation, and the robot is capable of understanding people's requests as well as learning new information. It can, for instance, provide weather information and let guests know at what time breakfast is served. Likewise, in Virginia, USA, Hilton has an AI member of staff. Like Sepp, robot Connie can provide helpful information to their guests and learn from its interactions. However, Connie's most impressive capability is its ability to make gestures, just as people do. IBM's Watson vice president and chief technology states, "When it is asked 'where's the elevator?', it says it's down the hall to the left while pointing down the hall to the left" (Fomby 2019).

Nonetheless, AI-driven robots are not the single domain in which AI is positively affecting the hospitality industry. In 2018, Avvio, a tech company, launched Allora, the world's first booking platform entirely run by machine learning. Traditional booking platforms are unsuccessful in delivering a personalized experience to their guests. Therefore, Allora consolidates multiple insights from different users and optimizes their experience by finding the best hotel and experience. The platform considers thousands of users' preferences based on geography, booking history, and other circumstances that impact the hotel selection (Allora 2021). A survey done by the online platform Booking unveiled that 75% of guests prefer self-service options thus, making chatbots another great benefit of AI in the hospitality industry. Chatbots are

capable of assisting with current reservations and answering common questions concerning hotel policies as well as transportation, changes in dates, check-in and check-out times and payments. Booking's chatbot is fitted to manage 50% of customers' "post-booking accommodation-related requests". If the chatbot is incapable of answering, the person will be redirected to a customer service member (Fomby 2019).

Despite all the great benefits that AI has delivered, there are still some risks concerning the implementation of AI in the hospitality industry. AI is still a very vast field, and although there has been significant development in recent times, the field is still very fresh, and AI is still developing. The previous vice president and AI leader of Google, Andrew Moore, even stated, "AI is currently very, very stupid". In fact, the term AI Stupidity is used to illustrate AI's inability to make sound decisions by only relying on the data that is available. As AI is based on human input, people are likely to provide inaccurate or biased data, thus leading to inaccurate or biased decisions. Additionally, businesses are further concerned about data privacy issues. Despite it being mandatory to follow data privacy laws and their ethical use, data collected during user interactions could be gathered for devious reasons. Hence, there is a significant risk of violating data privacy. However, if businesses were to obey every law and regulation, AI could become a significant source of competitive advantage (Fomby 2019). Likewise, data privacy issues are also a concern for customers. Many are reluctant to rely on information delivered by AI-based technologies completely, as the provided data depends on the program's quality and algorithms that make the technology work. Therefore, many customers will continue to seek human help, even when the required information is available (Roy 2021).

Another liability for implementing AI in the hospitality industry is that this type of technology is expensive to implement and costly to maintain. While technology is more easily attainable and there are several options available, most hospitality businesses may not have the budget to invest in AI-driven technologies, thus causing them to lose their competitive advantage (Koo,

C. et al. 2021). Finally, the most pressing risk of implementing AI in the hospitality industry is unemployment. Most people believe AI will replace humans due to new developments in technology. Workers in the hospitality industry are fearful for their jobs and anticipate AI will take over the more obsolete tasks, thus leaving many unemployed. A study developed by McKinsey Global Institute reveals that intelligent robots will replace 30% of the world's working population by 2030. Given the many different tasks that require minimal effort in hospitality, it is likely that most people will no longer be required and will, in fact, be replaced by some AI technology (Bughin et al. 2018).

#### **4.2.7 Industrial Products**

According to a Deloitte poll on AI adoption in manufacturing, 93 percent of businesses believe AI will be a key driver of growth and innovation in the industry (Deloitte 2019).

Artificial intelligence has, in many ways, revolutionised the industrial product industry. For instance, with the introduction of autonomous industrial robots, production improved significantly. Production can now be operational 24/7, while human beings need rest and regular maintenance. Robots do not get tired or hungry, and they can operate on the assembly line 24 hours a day, seven days a week. This enables the growth of manufacturing capacity, which is becoming increasingly essential to fulfil the expectations of global consumers (Rowse 2019). Additionally, robots are more efficient overall. Artificial intelligence technology ensures that products satisfy the necessary quality and regulatory requirements. Manufacturers can accomplish this by incorporating AI technologies such as machine learning and big data into their equipment, such as tracking sensors (Global Trade 2020). Safety is another topic that AI significantly improves in this sector. Humans are prone to making mistakes and are fallible. Errors and mishaps happen on the factory floor and in any building or processing setting; this is a problem that AI and robotic aid can almost completely eliminate. Furthermore, remote

access control necessitates a reduction of personnel, mainly when the activity is hazardous (Rowse 2019). AI also enables factories and industrial complexes to minimise operational costs.

According to Deloitte, manufacturing is predicted to generate 1,812 petabytes (PB) of data per year, outnumbering communications, banking, retail, and several other businesses (Deloitte 2019). Consequently, it can use and develop predictive that programs aid the sector in multiple stages of the business. For example, Data is collected in real-time to monitor the state of equipment in predictive maintenance scenarios. The idea is to uncover patterns that can assist forecast and ultimately prevent failures; AI systems are increasingly being employed to achieve this goal using learning algorithms. Plants can be more strategic when analysing equipment state and anticipating when maintenance should be conducted when predictive maintenance is automated (Stefanini Group 2020). Additionally, producers might synchronise production schedules to increase output. According to a report by McKinsey, an AI predictive maintenance model can boost productivity by 20% (McKinsey 2017). It can also save up to ten percent on maintenance costs. Aside from production, AI plays a vital role in other sectors of manufacturing. Distribution and supply networks, monitoring, customer behaviour, and changing patterns are all examples. As a result, AI in manufacturing ensures that businesses can anticipate market shifts. They can then strategize for better manufacturing and other cost management processes with this information. Manufacturers can also utilise AI algorithms to forecast market demand (Global Trade 2020).

Nonetheless, it also does have its disadvantages and challenges. First, the costs of implementing and maintaining artificial intelligence are substantial. For small businesses and start-ups, the budget is often prohibitively expensive. Even while artificial intelligence reduces labour costs, installation, and maintenance costs (Global Trade 2020). Another disadvantage of artificial intelligence is that it is vulnerable to cyber-attacks. According to a recent World Economic Forum research, cyber-attacks are among the top five global stability threats (World Economic

Forum 2019). For any manufacturer who uses AI software, this kind of information might be frightening. Finally, the scarcity of talent and expertise. Because these technologies necessitate complex programming frequently, it is critical to factor in expert availability. Furthermore, because such hands are in high demand, the cost of hiring them will be expensive. “Demand for workers with AI talent has more than doubled over the past three years, with the number of AI-related job postings as a share of all job postings up about 119%.” (Indeed 2018).

## **5. Investment in Artificial Intelligence**

### **5.1 Investment in Artificial Intelligence**

Artificial Intelligence changed and reshaped the behaviour of most companies, among it also on their investment approach and strategy. It is important to mention that the aspect of investments into AI must be divided into two segments: one the one side investments are conducted internally, therefore focusing on establishing and implementing own concepts through recruitment of personnel and purchase of assets. On the other hand, investment of AI is conducted through funding, Mergers & Acquisitions, or strategic funding's in external companies, that serve as an asset, to amplify the product portfolio or as a value addition to existing technologies and processes. The following part will analyse different aspects of investment activities within AI industry, focusing on the internal investments that companies have conducted and on differences between external investment throughout the last decade.

### **5.2 Overall Information of AI Investments**

IDC research in 2021 have estimated a global investment value of almost 342 billion USD only in 2021, forecasting further growth in the upcoming years by breaking the 500 billion USD mark until 2024. Mayor part (88%) relate to spending's on AI based Software, followed by expenditures in AI based hardware (Needham 2021). Within the industry, investments for “AI services” show the fastest development as it is forecasted at a CAGR (Compound Annual Growth Rate) of 21% and a total market volume of 50 billion USD by 2025 (Kenyon 2021).

Throughout the last 10 years, companies' investment in the own AI structures, processes and human resources have increased drastically as strong raising revenues of AI Enterprises indicate (Columbus, Forbes 2018). Whereas majority of companies had to make large budget cuts for operations during the Coronavirus Pandemic, investment in technology and mainly in AI were maintained or even increased over time (Kark, Gill and Smith 2021). Gartner Research data of 2020 indicate that 66% of organizations decided to actively fund new and existing AI related approaches to enhance “[...] customer experience [...], retention, and revenue growth – along with cost optimization [...]” (Stamford 2020) i. Moreover, 50% of companies of the Life Sciences, Energy, Retail Consumer Products, Telecommunications, Government and Automotive industry stated that they are “[...] progressing their AI efforts as planned or even quickened the pace of deployments” during the economic shutdown caused by COVID-19, indicating the overweighting benefits generated by AI based approaches (Liu 2020).

Based on OECD research of “Venture Capital Investments in Artificial Intelligence”, the AI industry is one of the most prosperous industries throughout the last years by growing an average of 34% Year to Year and being responsible for almost 75 billion USD in VC (Venture Capital) investments into AI companies alone in 2020 (Tricot, OECD 2021). Investments in US and China based companies are responsible for almost 80% of the monetary value of the investments creating an enormous gap towards the EU27 countries that represent an aggregated 9% of total investment volume. Not only has the amount of investment grown over the years (from 500 in 2021 to almost 3900 in 2019) (Tricot, OECD 2021), but also the average ticket size per each investment as it almost doubled in most of the regions. Moreover, changes can be identified in the average ticket size between 2012 and 2020. The amount of tickets with a size of 10 to 100 million USD per investment has almost been doubled, whereas as strong decrease (-17%) in investment tickets bellow 1 million USD can be recognized (Tricot, OECD 2021). Reason for such development is connected to changes in the approach towards start-ups, as the

aspect of long-term growth and maturation through large amounts of cash to finance their operations is accepted.

Furthermore, Crunchbase studies indicated that since 2000, investments in AI related companies have increased up to six times, making it one of the fastest growing industries (Columbus, Forrbes 2018). Further information from the OECD reports indicates that in 2020 over 20% of the overall investments conducted by Venture Capital are related to an AI focused company (Tricot, OECD 2021). Enlarged investments are mainly related to potential high return of investments due to the growing demand on customer side and constantly developing technological market standards.

### **5.3 Leading Investment Companies & Major Investments**

Most of the leading successful Venture Capital companies are based in the US and evolve companies such as Sequoia Capital, Y Combinator and Andreessen Horowitz. GlobalData announced Sequoia Capital as the most successful VC investor in the AI space in 2020 by having participated in 52 deals and investing over 400 million USD in 2020 alone (GlobalData 2021). The market is heavily disputed as market giants such as Meta Platforms, Amazon or Alphabet Group have also increased their efforts by acquiring and strategically investing in emerging companies with high technological standards. Google, nowadays Alphabet Group, are the largest investors among the leading technology elite by having acquired over 30 AI start-ups and having spent over 4 billion USD (Hurst 2020) on M&A activities since 2009. Among their top investments, the acquisitions of DeepMind in 2014 for over 500 million USD (Shu 2014) and the acquisition of Onward. Objective of the investments was to elevate the quality of the offered services by automating their processes and improving the customer experience on the respective platforms. Facebook, nowadays Meta Platforms, have acquired AI based companies such as AI.Reviere (Wiggers 2021), Bloosbury AI (for 23-23 million USD) (Ha 2018) and Scape Technologies (for 40 million USD) (O'Hear 2020) to improve their existing

NLP, Machine Learning and Virtual Recognition services (Shu 2014). Such investments by large entities have proved that certain know-how and human resources can only be obtained by acquiring smaller markets players, driving companies values to higher dimensions.

The traditional bootstrapping, therefore, the financing of future operations with own capital (Kenton 2020), is not a common practice among most AI start-ups, due to enormous costs connected to human resources, hardware, and license fees for software. This creates the opportunity for other type of investors such as Business Angels and Early-Stage investors, which gained on popularity throughout the last years within the AI industry. Among the successful Early-Stage investors Venture Capital companies such as Y Combinator or M12 can be found, which focusses on funding tickets bellow 50 million USD (GlobalData 2021).

It is important to differentiate by the final purpose of the investment. The activities of larger companies mostly tend to improve the already existing technology behind the own products, whereas the investment activates of smaller and medium sized companies also aims to expand the product portfolio.

On the one hand, this can be seen in large deals such as the acquisition of Nuance by Microsoft in 2021 (Baker, Porter and Dina 2021). The company was acquired for almost 20 billion USD to improve Microsoft conversational AI focused platform with its cutting-edge NLU (speech and text recognition) and NLP technology. Not only the Tech Giants have shown interest in the emerging industry, as for example players such as Panasonic acquired the supply chain-based company Blue Yonder in 2020 for 7 billion USD (Blue Yonder 2021). The electronics provider aims to “[...] aim to optimize the overall supply chain not only within single companies but also across companies.” (Panasonic 2021) An additional deal enhancing the strategy of acquiring external companies to improve the own product performance can be identified in the Zoox acquisition by Amazon in 2020. The E-Commerce giant acquired the autonomous driving

system for 1.2 billion USD to accelerate own developments for autonomous delivery vehicles with the objective of solving the last-mile issue and cutting mayor cost of delivery (About Amazon 2020).

On the other hand, the diversification of the portfolio can be seen in a company such as Zebra Technologies. The Illinois based designs, manufactures, and sells automatic identification and data capture products and amplified its product portfolio by acquiring Antuit.ai in 2021 (SupplyChainBrain 2021).

With Antuit omni-channel approach, Zebras Technology will be able to offer the services through new channels, increasing the value for its customers and their end-customers. Moreover, Ipsos also present a similar approach based on the most recent acquisitions of the companies Infotools (IPSOS 2021), Synthesio (IPSOS 2018) and Intrasonics (IPSOS 2021) for over 60 million USD through the last three years. In results in an expansion of services by acquiring players that focus on social media and audio, therefore implementing new sources of data to complement the conventional approach of the French market research company. An additional example consists in the MarTech (Marketing Technologies) leader Hootsuite. The Canadian company offers a unified solution of Social Media and Marketing Management, unifying different services of the industry. With the recent acquisition of HeyDay!, a conversational AI provider, for 60 million USD, Hootsuite plans to expand its operation into also helping its client automate its communication towards end client by using state of the art Natural Language Processing and Natural Language Understanding systems (Hootsuite 2021).

#### **5.4 Investment per Industries**

Based on the high penetration of the adaption of the digitalization by the beginning of the 20<sup>th</sup> century, it can be assumed that majority of the nowadays known industries are able to implement AI approaches. The industries differentiate by the degree of implementation of AI approaches, therefore also defining the scope and value of the companies with AI based

solutions. It is important to state that the AI industry it's an industry itself, yet the usability of it is always connected with other industries.

Based on OECD research of “Venture Capital Investments in Artificial Intelligence”, industries indicate strong differences in terms of ticket size and popularity during the timeframe of 2012 and 2020. In quantitatively numbers, the industries of IT infrastructure and hosting (2012-2020: 4063 deals = 19.8% of all deals), Media/Social Platforms/Marketing (2012-2020: 3351 deals = 16.3% of all deals), Business processes and support services (2012-2020: 2944 deals = 14.3% of all deals) and Healthcare, drugs, and biotechnology (2012-2020: 2545 deals = 12.4% of all deals) are the largest industries up to today (Tricot, OECD 2021). When comparing with the aggregated total value of all investments between the timeframe of 2012 and 2020, changes can be identified. The industry with the highest investment is the “Mobility and Autonomous Vehicles” industry, accounting for over 29% of the monetary value of the investments since 2012, yet slightly decreasing during the last years. Surprisingly none of the before mentioned industries are equalling the relative amounts of deals with the relative monetary value of the investments: IT infrastructure and hosting = 10% and steady performance of the years, Media/Social Platforms/Marketing = 11%, decreasing performance over the years and even reaching 6% in 2020, Business processes and support = 11% and steady performance of the years and Healthcare, drugs, and biotechnology = 10% and increasing performance of the years (Tricot, OECD 2021).

High investment in the Mobility and Autonomous Vehicles are connected to the factor of high cash burn and low margins. The large AI-based transportation services such as Uber, Bolt, Lyft and Didi received additional mayor cash injections to compensate the extensive cash burn during the initial phase for their operations, technology assets and marketing spending's (Lehtonen 2021). In addition, Googles' autonomous car manufacture Waymo had an impact by

raising almost 2.5 billion US in a second external investment round in 2021 (Alamalhodaiei 2021).

### **5.5 Investment by Geography**

When analysing the source of the investment related activities a very homogenous distribution among different regions can be identified. Mayor origin of deals is connected to the US and China, as they account for almost 72% of all closed deals between 2012 and 2020, accounting for almost 80% of the monetary value of the investments (Tricot, OECD 2021).

When comparing the US to China, US takes the clear role as the more active investor as they account for 174 billion USD in investments during the period of 2012 and 2020, accounting for more than 50% of all VC investments over this period. Throughout the years, China, and other countries such as UK, EU27, Japan and Israel started to increase the amount of investment, yet the American VCs still account 43% of all total investments in 2020 (Tricot, OECD 2021). EU27, mainly due to the investments from German and French VCs, performance throughout the years had a positive performance, as all countries increased the aggregated amount of invested money to a total of 7 billion USD and a total participation in 800 deals in 2020 (Tricto 2021).

It is important to differentiate between the factor of origin of the investing VC and the origin of the to be invested company. When comparing the activities on national terrain, China represents 70% of the investments in local firms, whereas the US only accounts for 60%. Mayor differences can be identified when it comes to investment outside the own country, as the US based VCs account for almost 20% - 24% of the globally conducted investments, excluding themselves and China. In comparison to this, China, accounts for only 5% of the globally conducted investments, excluding them itself and the US. This big difference indicates that the efforts from China are mainly focused on investing locally. Moreover, the investment landscape

in China changed due to foundation of government-led incubators and the raise of strong Chinese technology firms such as Alibaba, JD or Baidu (Tricot, OECD 2021).

## **5.6 Investment Trends in the AI Industry**

The heavily increasing investments throughout the whole world strongly indicate a prosperous future for the industry. Yet, as presented in 1.3 and 1.4, certain industries have experienced a decrease in demand, influenced by the geolocation or the change in customer requirements.

Assessing future trends in the AI industry can be approached from different perspectives, as it can be analysed from an industry point of view or on a more technological point of view.

When performing an analyse of the industry point of view, industries such as the Mobility and Autonomous Vehicles will continue growing due to the raising demands for cars working based on renewable energies and the constantly increasing fuel prices caused by limited natural resources.

When performing an analyse of the technological point of view, three mayor trends will be the main challenge according to the Yang Lu from Antai College of Economics and Management, Shanghai Jiao Tong University: development of platforms, algorithms, and interfaces (Lu 2019). According to Professor Lu, future developments should focus on creating platforms that can perform at a higher level, therefore processing larger amount of data in a shorter time. Such requirement is closely connected with Hardware AI providers such as NVIDIA, Intel or Google that are already working on next generation (GPU = Graphics Processing Unit instead of CPU = Central Processing Unit) devices to fulfil those demands. In addition to this, platforms shall develop own approaches to combat increasing to prevent malicious processes and threads, making them event more secure against Cybersecurity related issues (Doshi-Velez and Kim 2017). Yang Lu indicates that the future development of the algorithms should aim changing from an “artificial intelligence” towards an “humanoid intelligence”, therefore preparing

algorithms to adapt to changing circumstances in the social world and combine it with the material world (Lu 2019). Last but not least, the development in regards of the interface should combine the factor to a very elaborated and professional back end with an user friendly front-end to prevent any kind of usage problems on the platform and therefore also decrease unnecessary expenses on Customer Support.

## **6 Artificial Intelligence in Banking**

### **6.1 Opportunity for Banks**

Today, banks are not questioning whether they should focus and invest in AI techniques and algorithms or not – this decision was taken long ago, but the adoption is only starting.

According to a survey from Deloitte that wishes to analyse the importance of AI in the success of the organizations in the next two years, 86% of the respondents said that AI will be very or critically important (Deloitte US 2021). However, it is important to understand what AI is and how it might impact businesses instead of just follow the hype around the topic – there is the need for a strategic guide. While some banks still think that AI is useful to make experiments on some products and processes, others are already taking these experiments into large scale and powering their businesses through intelligent tools that automate back-office tasks such as Know-Your-Customer (KYC) procedures or credit scoring decisions, but also communication channels like chatbots.

“The world’s most valuable resource is no longer oil, but data” (The Economist 2017), and that is the greatest opportunity for banks. Financial institutions have access to the purchasing records from each of its clients, and when analysed these can give powerful insights on default and credit risk, cross-selling (e.g., propose an insurance product after the purchasing of a car), and many other applications that will be later explored.

First, this section has an initial part that analyses how a bank is organized and how the value chain is composed, and then it will analyse the rising importance of banking data because of increasing internet and mobile applications adoption, and a snapshot of how high this will be was already given here. The second part of this section will be built on the work done in the first one, plus the results of qualitative interviews answered by experts in financial services in the Portuguese landscape, and a quantitative survey to understand the perspectives of the clients of a bank regarding the communication channels they use, and their need of going to a physical branch. In that second block, this work will present what are the current applications of AI in the financial services sector and how banks are already leveraging these techniques. Moreover, it will define if the banking ecosystem is moving towards a scenario of cooperation or competition between FinTech firms and banks, and what we can expect from the existence and operation of physical branches. Specifically for this last topic, the main conclusions will be a merge of the opinions of experts and the expectations of customers.

## **6.2 Research Methodology**

This project is integrated in joint research on how AI is impacting digital businesses, focusing on measuring, and understanding this impact specifically in the financial services sector.

The main objective is to answer the following questions:

- (1) How are banks organized, which are the main products and processes, and how can data help?
- (2) What is the state of the art and the impact of Artificial Intelligence in the banking sector?
- (3) Where is the banking sector going in terms of the relationship with FinTech firms and the existence of physical branches?

To answer the proposed questions, this study will focus on a qualitative research methodology through an interview made to experts and a quantitative survey made to the general population.

These interviews were performed to gain multiple insights on how banks are leveraging AI techniques to scale their business, and that is why we chose to interview specialists in management roles at financial institutions in Portugal. In appendix A it is present what are the questions and the profiles from the experts interviewed.

To guide the experts through the questionnaire, the following topics were accessed: 1) is AI a must for banks to deliver better and increase the customer base and retention; 2) what is the state of the art of AI in banking right now, regarding the main applications and benefits and risks; 3) what are the future trends shaping the future of AI in the banking industry; 4) will the technological developments come from in-house or through cooperation with FinTech companies; 5) what is the future of physical branches and their role in society.

The qualitative survey focused on understanding the customers' expectations about digital banking services, and whether they believe or not that most activities and product will be transferred to the online sphere. To do so, the survey consisted in 178 answers from individuals with a diversified demographic and academic background and tried to find: 1) will products like loans move to the online or will they stay on the branches; 2) which are the preferred communication channels; 3) will virtual assistants' impact increase in the future. In appendix B it is described how the survey was organized.

## **7 Banking and the generation of data**

### **7.1 Understanding a Bank's Organization**

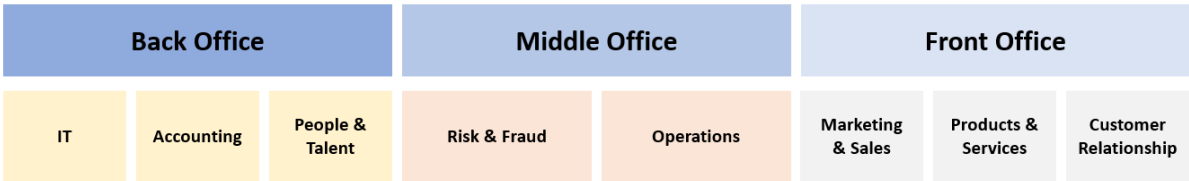
Before deep diving on the main applications, trends, and future of AI in the Banking industry, it is important to understand the organization of a bank and its main components, as well as the principal operations and revenue streams (i.e., products and services), to better see how AI can impact these. After defining each area and the main products and services, it is possible to build the full value chain of the bank.

According to (Deloitte US 2021), we can define three main blocks of action:

- 1. Front office:** this area comprises all the operations and interactions that directly connect with the final customer, through agents such as salespeople or branch managers (Deloitte 2020).
- 2. Products and services:** in here are included all the products and services offered by banks to its clients, such as checking and savings accounts, loans, mortgages, the distribution of debit and credit cards, insurance, advisory, etc. This applies to both individual and institutional clients.
- 3. Back office:** this area is made by the administrative and support people that do not face clients, with areas such as IT and Data & Analytics, accounting, regulatory reporting and compliance, fraud and money laundering prevention, audit, and service optimization.

Given this and the experts' input, we have the ingredients to build our banking value chain and start exploring the applications of AI on each sector of it. Thus, we can define the value chain by having a back-office, a middle-office that will do the connection between both, and a front-office. In the back-office, we will have the IT, accounting, and the people and talent teams. In the middle-office, we will have the operations and risk management teams. In the front-office, we will have the marketing and sales, products and services, and customer relationship teams.

Figure 1: The banking value chain (based on Author)



This definition is important to then resume the main applications of AI within the chain, as well as its trends and their impact in the ecosystem and the future of branches. It is also important to understand this breakdown since although most of the areas will benefit from AI, not every

product and service or department will benefit from it in the same way. However, we can conclude that by having so many products and services that connect directly to clients, this will generate huge amounts of data that needs to be treated. In the next section, it is presented if the data generated by banks is valuable or not.

## **7.2 The Value of Banking Data**

First, there is the need to introduce the concept of Big Data. This is a concept associated with three Vs: volume, variety, and velocity. Volume matters, since big data comes associated with high volumes of unstructured and low-density data, and this might come from several sources and not only the banking transactions, proving the second V. At last, data is generated quicker and so there is the need to treat this in real time (Oracle 2021). The usage of mobile banking applications skyrocketed in the last months, and the root of that might be the pandemic. The market penetration for all generations of ages increased from December 2020 to May 2021. For Generation Z, it went from 86% to 95%; for Millennials, from 83% to 91%; for Generation X, from 73% to 85%; for Baby Boomers, from 42% to 60%; for Seniors, from 18% to 27% (Forbes 2021). The increase in the usage of mobile applications rose, meaning that all providers are now collecting more data that needs to be treated in real time to become valuable.

As said before, if there is a type of data that really defines someone is the record of the purchases done. Let's imagine the following example: there is someone that loves tennis. Considering an individual that has an account on a social network and follows all the tennis players in the world, plus the pages that share content about tournaments and points. What will tennis brands target when they do advertising? People like this individual. And these brands will spend money targeting it, trying to get it to spend money on tennis products.

Now let's go for the data available at the bank. This individual is 40 years old and never did a purchase on a merchant related to tennis, never rent a court to play and never bought a ticket to

a tournament. This means that the marketing money allocated to this user will be useless, but the bank has valuable data and needs to treat it.

It is estimated that 30% of the actual revenue streams of a bank disappear in the following 20 years due to the rise of neo and challenger banks, regulatory changes and pressure, and the increased number of transactions and investments done in cryptocurrencies (Accenture 2018). This is an alarm – banks should push hard to collect valuable insights from data and do not let their customers slip away. Also in this report, there is evidence of a large player in the United States that added 1.2 billion USD in annual revenue by partnering with merchants to perform marketing campaigns powered by banking data insights to increase conversion in their sales. The conversion rate of the bank rose to 3.5%, contrasting with the 0.4% average on the industry.

McKinsey found that the potential annual value of AI, traditional or advanced, to the banking industry can sum up to 1 trillion USD, representing 15% of sales. The sectors and activities of the bank that can benefit the most from this are related to marketing and sales and can have a value up to 625 billion USD. Inside this department, the most relevant use cases where AI can add value are related to customer service management, with optimized call centres that predict the times with more demand or voice recognition to immediately have a specialist speaking to that person to avoid churn, but there is also opportunity for pricing and promotion with the application of algorithms to introduce personalized pricing and increase conversion. Risk management can also benefit a lot from AI, with a potential annual value up to 372 billion USD, through the usage of analytics to detect and prevent fraud and money laundering, and to better preview potential defaults on loans. Then, also human resources, finance and IT, and other operations can benefit from AI, but at a much lower scale (McKinsey 2018).

So yes, banking data is valuable, and has a lot to explore. What drives AI is the amount of data available, and that is already happening in the banking sector. In the next section, we will deep

dive on the current applications of AI in the banking industry and how banks are currently leveraging the huge amounts of data collected to scale their businesses.

## **8 The state of the art of Artificial Intelligence in Banking**

Artificial Intelligence is already applicable in the whole value chain of the bank. However, only in the last few years we have been seeing these techniques extend to the touchpoints of the bank with its customers. The first developments in AI started in the back-office operations, with the creation of algorithms and procedures to automate tasks such as credit scoring, fraud detection and anti-money laundering schemes – the rise of Robotic Process Automation (RPA), that will combine several AI techniques as we will see further. These algorithms can be useful for several duties, such as mortgage processing, KYC procedures, report automation, and many more examples, allowing to reduce costs, human errors and increase efficiency. That also means that banks were already using data from the front-office to feed these algorithms but were not treating it in a way that would benefit their relationships with their customers, mainly in managing expectations and creating services that are tailored and personalized to the customers' needs.

To automate tasks such as credit scoring and fraud detection, these algorithms need to analyse millions of records to make better predictions. This is done through Machine Learning algorithms. Also, banks are leveraging AI techniques to perform the exact same back-office tasks that are repeated and time-consuming. This includes scanning documents and digital signatures, reducing the paperwork, and is powered by Computer Vision techniques. Finally, NLP is being used to power voice and chat assistants, to help customers to interact in an easier way with the bank.

Resuming, and according to the experts' inputs and the study performed, we can state that the main AI techniques being used in the banking sector right now are Machine Learning,

Computer Vision and NLP. We will see which are the use cases mentioned for each technology described.

## **8.1 Machine Learning**

Predictive analytics and classification problems are powered by ML techniques. These are helping the back-office tasks of a bank getting smoother and more accurate, with less human intervention and giving results faster. If one were to analyse the transactions of a bank one-by-one, doing fraudulent transactions would be easy. These techniques are helping not only to better predict credit defaults and to monitor risk, but also to verify the real identity of a customer.

Money laundering refers to the process from which criminals can disguise illegal transactions as legal sources of property and income, transforming this income into legal money (Banco de Portugal 2021). Therefore, banks need to focus on anti-money laundering (AML) mechanisms to prevent fraud and terrorism financing. With the pandemic of COVID-19 people shifted more of their transactions to the digital space, through e-commerce platforms and with digital means (such as wallets or NFC payments), rising the number of actions related to AML – this number was already rising, but the pandemic was a factor to deepen this problem. In e-commerce, for instance, criminals see a good opportunity to pose as legal merchants and can easily collect money from the less informed buyers (McKinsey 2019).

Also, ML is powering credit scoring to better predict defaults and decide whether a customer is trustworthy or not. With the expansion of the banking business, credit card and personal loan applications are also rising, and the decision needs to be done immediately to better serve customers. Banks use the purchasing records of their customers to make instantaneous credit decisions, and thus speed up this process. This is also enabling the approval of loans through digital channels, without the need of going to a physical branch, which increases the

convenience of the service. With more data, algorithms get more accurate, and the risk of default gets lower with time. Both use cases specified contribute heavily to better manage and thus reduce risk.

Finally, authentication methods such as Face ID (that allows to do a login in a mobile banking app) or fingerprint scanning are also using DL algorithms to make sure that no one can access an account besides the real owner of it. iPhone users can log in to their accounts or make payments using the Face ID system provided by the phone, that places thousands of infrared dots on the face of the person that is trying to authenticate and compares it to the original picture provided (Apple 2021).

## **8.2 Computer Vision**

Computer Vision allows to analyse pictures and videos and turn them into valuable and verified information due to the recent development of DL algorithms for financial services (Forbes 2019).

The first main advantage of this technology is the digital onboarding of clients, performed with in-app KYC, eliminating the need to go to a branch to open an account. Customers are required to make a video-call (in the case of Moey!, the digital bank created by Crédito Agrícola in Portugal) – where they will speak with a real human, take a selfie and scan an identity card, all without leaving the call (ECO 2019) – or to just upload the photos of the required documents (in the case of Revolut) – a photo of the national identity card, plus a selfie, and the algorithm does the match (Revolut 2019). These speeds up the process of getting a new client and diminishes the risk of losing it during the onboarding process.

Another main application of this technology in the banking sector is a complement to the digital KYC procedures, and is the digital scanning of documents, previously done manually by humans. The documents, when in paper, are easy to get lost, to be damaged or to be mistreated,

and the technology is here to help reducing the human error and increase efficiency – by automatically understand which is the type of document that is being scanned and what is the information stored in it, like in *Revolut's* onboarding. When opening a bank account online, the user needs to enter its personal information but also needs to submit some documents, that sometimes come in a picture format. Computer Vision algorithms, combines with NLP that will be explained after, will take care of the situation, and make sure that all the information is treated and stored.

### **8.3 Natural Language Processing**

Picking where we were, the text present on the documents scanned during, for example, KYC operations needs to be analysed and compliant with the other data provided in editable fields such as the name or the date of birth – when the identity card is uploaded, that information needs to match the one provided manually by the client. Also, legal teams are leveraging NLP techniques to review large bulks of long documents – the algorithms are created to identify what is marked as important and retrieve that information to the analysts. Finally, other client data different from the transactions done by card or transfers that reaches the bank can be an opportunity to explore cross-selling or identify the client's needs – for example, the posts a client makes about its bank on social media turns it easy to detect whether it is happy with the service or not.

The other use case of NLP within the banking industry is associated with customer service, that today is required on demand. Banks are using chatbots and virtual assistants to communicate with their clients since these need their problems to be solved in real time. For instance, a client can use a chatbot to perform basic banking operations such as check the account balance or make a transfer, but also to solve technical issues and get information about products, services, schedules, and so on. However, in the survey performed, 73% of the respondents said that they would not use voice commands to perform basic operations such as checking balances or make

transfers. But the perspectives are good, since the share that says they would do it in 10 years from now is 63%, showing that the trend exists. Also, 71% said that chatbots are indifferent, mostly irrelevant, or irrelevant when asked to classify that as a feature of a bank.

This is where we are today (and will continue to be). In the next section, we will see if these technological developments will come from in-house or from third party providers.

## **9 FinTechs: Friend or Foe**

FinTechs such as challenger banks that operate in a Business-to-Consumer (B2C) model cannot be seen as an enemy of banks right now since they do not have the same business model. A bank captures deposits to transform these into loans or investments in securities, and that is the main activity – the interest rate spread gives a profit. Then, of course, they have several other revenue streams such as commissions charged on account and card maintenance, commissions on trading accounts, insurance products or investment products – and usually, challenger banks do not charge for any of these. If we look at the business model of a challenger bank like N26 or Revolut, we can see that they do not offer the same loan products that incumbents offer, and thus cannot be seen as a big rival in this segment. For instance, Revolut has some of its clients' deposits safe since they are deposited in other big banks (Revolut 2021), showing that even these are depending on the incumbents to survive right now. Also, looking at this breakdown of the incumbents' revenues and checking that challenger banks do not have these as revenue streams and are incurring in huge operational losses – Revolut had \$280 million in 2020 (Bloomberg 2021) – we are allowed to ask if these business models are good after all.

However, when we talk about FinTechs that operate with a Business-to-Business (B2B) model, the panorama changes. These are firms that are offering their services to banks, in a clear statement that they exist to cooperate and there is work for everyone. If we look at the Portuguese banking landscape, we can see that: Caixa Geral de Depósitos is using Tink's account aggregation and payment initiation engines to provide an open banking experience to

their clients (Tink 2019); Crédito Agrícola invested and partnered with Meniga to power their digital transformation experience and launch Moey!, a fully-digital bank (Echo Boomer 2019); Feedzai, a Portuguese unicorn valued at 1.5bn USD (ECO 2021) established in 2011 that now is the market leader in fighting criminal transactions by providing software to financial institutions, is helping banks such as Citi, Lloyds Bank, ABN AMRO and Santander to better monitor risk and prevent fraud.

Given this, all the experts said that, although some developments might come from in-house, most of the back-office and routine tasks will be automated through partnerships with FinTechs. Around 46% of banks are planning to create more partnerships with FinTechs in 2022, while this value was 32% in 2020. Also, in the first half of 2021, the United Kingdom's FinTechs received more than £4.1 billion, while the total investment in 2019 was £3.3 billion (Lloyds Bank 2021). Analysing the experts' opinion and the facts above, we can conclude that FinTechs are here to help maturing solutions, save costs, get more efficient processes, and allow banks to scale their businesses. Therefore, they will stay around and cooperate even more with banks in the next years.

All these technologies and developments are impacting the workplace, as well. While algorithms automate back-office and routine procedures, it might be the case that the job at a physical office or branch also changes. In the next section, we will discuss the future role of physical branches and how these are being impacted by digitalization.

## **10 The Future of Physical Branches**

Right now, physical branches are here to stay, although the absolute number of locations per million people is dropping in North America, the United Kingdom, and Europe, showing the evidence that there were too many and representing unnecessary costs (McKinsey 2019). These will not disappear in the short run – the ones that keep operating will serve as strategic locations to serve a higher number of clients. With the empowerment of AI in the industry, customers are

also embracing a more digital culture as we could see in chapter 2.2., meaning that most of the operations that were previously done in the branch are already done online – and the back-office operations performed at the branch are being substituted or at least helped by AI. However, the landscape changes when we think about the future – specifically 10 years from now.

In the survey performed to study the customers' expectations about banks, there is evidence of their will to still go to a physical branch to take care of a specific product – loans. In the investigation performed, today the physical branch is the preferred channel to buy a loan, whatever the category (personal, student, home, car, and business). 72% would use a physical branch to purchase a home loan, and the same percentage applies to business loans. Lower dimension loans such as the personal or the student ones have lower percentages of customers desiring to have them in the branch – 45% and 43% respectively.

That will change in the future. 10 years from now, the app would be the preferred channel to buy any type of loan, while the physical branch is the least preferred for every category except for the home and business loans (this was expected after analysing today's results). In the future, 84% would use digital channels to buy a personal loan (the website or the app), being the app the most preferred channel. 73% would use digital channels to buy a home loan, completely reverting the trend found today. More detailed results can be found in the table in appendix B.2.

Concluding, we can expect the number of branches to keep decreasing in the next years, but these will not disappear. Most services will be transferred to the online sphere and these locations will be transformed in customer service centres not so focused on sales, but the human touch still needs to be there in the long run and will be for sure.

## **11 Conclusion**

After all the contents analysed there is a solid ground to answer the research questions proposed in the beginning of this paper. The first question was linked to the bank's organization and the

value of data. We can organize the value chain in three major blocks: 1) the back-office, composed by the IT, accounting, and people and talent departments; 2) the middle-office, composed by the risk management department that deals with situation such as fraud detection, and the operations team; 3) the front-office that deals directly with the final customer, and is composed by the sales and marketing teams, the products and services offer, and the customer relationship managers. All these products and services commercialized by a bank will generate huge amounts of data that are serving as fuel to the back and middle office engines. Data is, indeed, of great value since it allows to characterize customers, group them into clusters, classify their default probability and reduce the default rate, cross-sell products, and many other examples – that will be developed principally for front-office activities.

The second question aimed at finding which are the principal applications of AI in the banking activity and their impact. Here, we found that the major technologies are ML, Computer Vision and NLP. These allow to develop solutions concerning fraud detection and anti-money laundering, authentication methods, KYC, scanning and finding information on documents, and virtual assistance to the customer. A great benefit to the bank comes associated with a lower default rate, thus increasing the revenue. Also, this speeds processes such as an account opening or document scanning, saving costs and working faster. For the final customer, products and services are available on-demand and in real time and coming at lower costs. However, there might be the case of bias in the ML algorithms, for instance, and that is a possible limitation from these implementations. The sum up, the biggest impact right now is coming from the back and middle-office tools that exist to save on basic procedures and to better manage risk. The great potential of data will drive marketing and sales in the future, with a more accurate client targeting and a better strategy to increase retention.

Finally, physical branches are going to transform themselves into customer service centres, located strategically, to decrease the number of branches spread through a country. Human

touch will still exist, but through less physical places, and this shift to the online sphere allows to save on people and infrastructure costs and increase productivity.

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## **Appendices**

### **Appendix A – Interviews to Experts**

#### **Appendix A.1. – Questions**

- 1) Do you think that AI, today, is a must for banks and there is a race to become AI driven and get in the front row to better serve customers and gain new ones, but also to create more efficiency in procedures and operations?
- 2) What is the state of AI in the banking industry right now? Which are the sectors and activities already leveraging AI techniques, the use cases and the main benefits and risks?
- 3) Will these developments come from in-house, or will they rely on third party providers? Is this a crucial time to include FinTechs in the financial ecosystem?
- 4) What do you think will happen to physical branches in the near future? And in the long run?
- 5) What can we expect for the near future (i.e., main trends)? Which sectors and activities are starting or will be benefiting even more from AI, and which are the use cases?

#### **Appendix A.2. – Profile of the experts**

Expert 1 is a C-Level executive at Santander Portugal, working in this institution for almost 20 years. He was already part of the executive committee and the leadership of the insurance

branch. He holds a degree in management and has studied across several schools such as INSEAD and Harvard Business School.

Expert 2 is the Chairman at Banco CTT, but also an advisor for Morgan Stanley, visiting professor at Nova SBE and a research associate at the London School of Economics. He holds a PhD in Economics from the University of Chicago and previously worked in companies like Oliver Wyman and the Portuguese Treasury and Debt Management Agency.

Expert 3 is a Director at Banco de Investimento Global. He is responsible for the Digital Strategy and Development department at the bank and is responsible for the Venture Capital side. He is also a visiting professor at Católica SBE and the co-founder of Portugal FinTech.

## **Appendix B – Survey**

### **Appendix B.1. – Original Structure of the Survey**

*Artificial Intelligence (AI) is changing the way products and services interact with their final customers. Banks today have a huge challenge in complying with all the technological advance in course and have to move faster than ever.*

*This research is being conducted by a Nova School Business & Economics student, to complete a thesis on "Artificial Intelligence in Digital Business", and it aims to find out what is the perception of final consumers on the current and possible features a bank might offer.*

*Your help matters! Expect to complete this survey in no more than 5 minutes. Thank you!*

*All the answer are anonymous and will be analysed as a group of observations, and not individually.*

Q1 – Gender (Man, Woman, Prefer not to say)

Q2 – Age (< 18, 18 - 24, 25 - 34, 35 - 44, 45 - 54, 55 - 64, > 65)

Q3 – Education (Basic education, secondary education, bachelor's, post-graduation, master's, PhD)

Q3 – Current situation (not employed, student, student-employed, employed)

*Traditional banks are the banks we are used to see when we are walking down the street, with a physical branch. In Portugal, there are major players in this industry such as Santander, Caixa Geral de Depósitos or novobanco. Out there, we could use the examples of ABN Amro (Netherlands), HSBC (UK), Deutsche Bank (Germany), Crédite Agricole (France), among others.*

Q4 – In how many traditional banks do you have an account open? (0, 1, 2, 3 or more)

Q5 – What is your favourite channel to manage your account? (App, website, phone call, e-mail, going to the physical branch)

Q6 – What are the characteristics you value the most in your bank? Scale them as: Not relevant, mostly not relevant, indifferent, mostly relevant, relevant. (Security, pricing, app features, card design, client support)

Q7 – You need to talk to your bank because something is not working with your bank account. How would you classify the following channels to contact your bank? Scale them as: Not relevant, mostly not relevant, indifferent, mostly relevant, relevant. (Phone call, going to the branch, chatbot, e-mail)

*“Neobanks, sometimes referred to as “challenger banks,” are FinTech firms that offer apps, software and other technologies to streamline mobile and online banking. These FinTechs generally specialize in particular financial products, like checking and savings accounts. They also tend to be nimbler and more transparent than their megabank counterparts, even though many of them partner with such institutions to insure their financial products.” Forbes 2021*

*This definition includes firms such as Revolut, N26, Monzo, Starling Bank and Moey.*

Q8 – Do you have an account open in a neobank like Revolut or N26? (Yes, No)

Q9.1 – On what degree do you agree with the following sentence: I opened the account because... Scale them as: Totally disagree, somewhat disagree, neither agree nor disagree, somewhat agree, totally agree. (... it is free, ... it pays no commissions on purchases abroad, ... it is trendy, ... the app is cool)

Q9.2 – What could describe the main reason for not having this type of account? (I never heard of it, I don't need to have one, I don't feel safe)

Q10 – How would you value the following banking features of an app? Scale them as: Not relevant, mostly not relevant, indifferent, mostly relevant, relevant. (Checking balances, free transfers, virtual debit card, savings account, budgeting, account aggregation, trading, exchanging cryptocurrencies, robot-advisor, chatbot, instant push notifications)

Q11 – Would you change your primary account from your principal bank to a neobank because of innovative features such as the ones described above? (Yes, no)

Q12 – Select the channels you would use to buy the following loans today: Physical branch, website, app. (Personal loan, student loan, home loan, car loan, business loan)

Q13 – 10 years from now, where do you expect to buy the exact same loans: Physical branch, website, app. (Personal loan, student loan, home loan, car loan, business loan)

Q14 – Would you use voice commands to check your account balance or to make a bank transfer? (Yes, no)

Q15 – 10 years from now, do you think you will use voice command to check your account balance or to make a transfer?

## Appendix B.2. – Key results

*Answer to questions 12 and 13 from the survey*

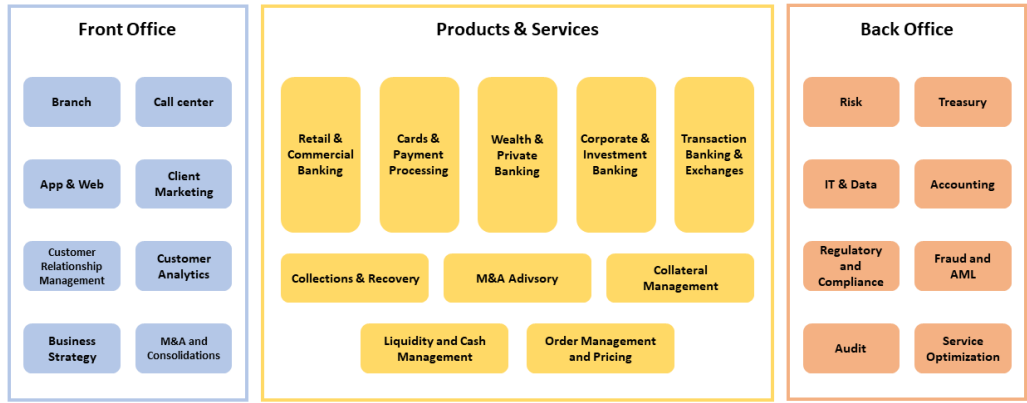
<b>TODAY - Absolute</b>					
Preferred Channel	Personal	Student	Home	Car	Business
<b>Branch</b>	<b>78</b>	<b>75</b>	<b>125</b>	<b>97</b>	<b>125</b>
Website	38	43	21	37	22
App	57	55	27	39	26

<b>TODAY - Percentage</b>					
Preferred Channel	Personal	Student	Home	Car	Business
<b>Branch</b>	<b>45%</b>	<b>43%</b>	<b>72%</b>	<b>56%</b>	<b>72%</b>
Website	22%	25%	12%	21%	13%
App	33%	32%	16%	23%	15%

<b>IN 10 YEARS - Absolute</b>					
Preferred Channel	Personal	Student	Home	Car	Business
Branch	27	25	46	29	49
Website	30	28	31	35	35
<b>App</b>	<b>116</b>	<b>120</b>	<b>96</b>	<b>109</b>	<b>89</b>

<b>IN 10 YEARS - Percentage</b>					
Preferred Channel	Personal	Student	Home	Car	Business
Branch	16%	14%	27%	17%	28%
Website	17%	16%	18%	20%	20%
<b>App</b>	<b>67%</b>	<b>69%</b>	<b>55%</b>	<b>63%</b>	<b>51%</b>

## Appendix C – Figures



**Appendix C.1.:** The organization of a bank (source: (Deloitte US 2021))

Machine Learning	Computer Vision	Natural Language Processing
Anti-money laundering	KYC	Chatbots
Fraud detection	Scanning documents	Virtual assistance
Authentication		Finding information on documents

**Appendix C.2.:** The main applications of AI in the banking industry

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