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Forging AI Pathways: Portugal's Journey within the EU Digital Landscape

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Abstract

This GEE paper provides a comprehensive assessment of the potential and challenges of Artificial Intelligence (AI), with a particular focus on Portugal in the context of the EU. Grounded in both global and EU contexts, the study identifies applications and transformative influence of AI across various sectors such as education, health, tourism, manufacturing, financial services or e-government. It also delves into the ethical, social and legal implications of widespread AI adoption, including data privacy concerns and the need for human oversight.

The paper examines EU's current stance and policies on AI. Recognizing Portugal's particular opportunities, the study provides strategic recommendations for fostering AI education and training, promoting research and development, supporting AI startups and businesses, ensuring ethical use of AI and encouraging international collaboration.

The implications of these strategies extend beyond technological advancement, touching upon broader societal, economic and philosophical issues. The future of AI is also approached, acknowledging both its potential and the inherent challenges of regulating this rapidly evolving field.

While this paper provides an analysis of AI within Portugal's context, it is subject to certain limitations, where future research is needed. As the AI landscape continues to evolve, so will the opportunities and challenges it presents, requiring continuous study and proactive policymaking.

The study concludes with a reflection on humanity's role in an increasingly automated world, underscoring the importance of balancing AI integration with the preservation of human values. As the architects of AI, mankind carries the responsibility to guide its path and its impact on our existence. We urge for the application of this power with prudence, foresight and empathy, to envision a future where humans and AI may not only coexist but prosper together.

Finally, the future of AI is not merely a technological evolution but a chapter in humanity's journey, echoing our choices. It is a future we create, a narrative we pen and a legacy we leave.

JEL Classification: K20, L86, O33, Q55

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Note: ***This article is sole responsibility of the authors and do not necessarily reflect the positions of GEE or the Portuguese Ministry of Economy and Maritime Affairs*.**

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"Humanity has the stars in its future, and that future is too important to be lost under the burden of juvenile folly and ignorant superstition."

Isaac Asimov, "Foundation"

1. Introduction

As we immerse ourselves in the Digital Age, **Artificial Intelligence (AI)** stands at the forefront of transformative technologies that promise to **reshape various aspects of our lives**. AI presents an array of **opportunities**, while also posing profound **challenges** that need careful consideration.

This paper proposes to provide a **comprehensive exploration of AI's current state, its applications and its implications**, with a particular emphasis on the European Union (EU) and Portugal.

Chapter 1 seeks to lay a foundation for the discussion that follows, **defining AI**, tracing its **history** and outlining its **importance and prevalence**. Understanding these basic concepts is crucial to understand AI's significance in the contemporary digital economy and society.

Chapter 2 explores various **applications and innovations where AI is thriving**. From healthcare to e-government, these sectors show the broad scope and transformative potential of AI in different areas of society and industry. Notably, we explore how AI is contributing to the achievement of the United Nations **Sustainable Development Goals (SDG)**, indicating its potential for positive impact in different objectives.

In Chapter 3, the focus shifts to the **role of AI in the digital economy**. We analyse the **economic impacts, market trends and projections** associated with AI, considering the EU's position in the global AI market and examining opportunities specifically for the Portuguese economy.

Chapter 4 grapples with the **challenges and ethical considerations** surrounding AI. This chapter sheds light on the risks posed by AI in terms of data privacy and security, potential job displacement and ethical considerations. It presents **case studies** that exemplify these dilemmas, highlighting the complexity and multifaceted nature of AI's ethical implications.

Chapter 5 analyses the existing **EU policies and regulations on AI**, aiming to comprehend the balance that the EU seeks to strike between fostering AI development and enforcing stringent regulation. It also explores **how these policies and regulations are likely to impact Portugal** as a Member-State of the EU.

Chapter 6 provides **recommendations for Portugal's AI strategy**, considering policies, opportunities for collaboration and potential areas of focus for AI development. The aim is to guide Portugal in **leveraging AI's benefits while mitigating the potential risks and challenges**.

Chapter 7 concludes the paper with a **summary of key findings and a future outlook**, encapsulating the insights gained throughout the paper and suggesting what lies ahead in the landscape of AI.

By navigating these diverse dimensions of AI, the paper aims to **generate a nuanced understanding** of this key technology, enabling informed discussions and decisions in policy, industry and society, particularly in the context of Portugal and the EU.

1.1. Definition of AI

AI is a field that can be defined in multiple ways, but it generally involves the "development of **computer systems** that **perform tasks that normally require human intelligence**" (Schultz-Wirth, 2018).

AI is a multifaceted field with various interpretations and definitions, often dependent on the **context** in which it is applied.

According to Copeland (2023), AI is characterized by "the ability of a digital computer or computer-controlled robot to **perform tasks** commonly associated with **intelligent beings**" (Britannica, 2023).

The Stanford Encyclopedia of Philosophy interprets AI as the field dedicated to devising **"artificial creatures"** that **mimic animal or human behavior** in certain contexts, and highlights its deep-rooted connection with **philosophy**, particularly through methodologies like first-order logic, intentional logics, inductive logic, probability theory, and practical reasoning. (Stanford University, 2018).

IBM provides additional context, stating that "at its simplest form, artificial intelligence is a field, which combines **computer science and robust datasets**, to enable **problem-solving**" and that it also "encompasses sub-fields of **machine learning** and **deep learning**, which are frequently mentioned in conjunction with artificial intelligence" (IBM, 2023).

Ola (2023) further expands on this definition, stating that AI "is intelligence —**perceiving, synthesizing and inferring information**—demonstrated by machines, as opposed to intelligence displayed by non-human animals or by humans".

West and Allen (2018), on the other hand, defines AI as "**machines** that respond to **stimulation** consistent with **traditional responses from humans**, given the human capacity for contemplation, judgment and intention." In other words, these are software systems that make **decisions** requiring a "**human level of expertise**" and help anticipate problems or address issues as they come up. Therefore, they operate in an "**intentional, intelligent, and adaptive manner**".

Schroer (2023) highlights some **concepts in AI** that enable innovative applications:

- **AI**: AI is a field within computer science that aims to create **intelligent machines** capable of performing tasks **usually requiring human intelligence**. It seeks to replicate or enhance human **cognitive abilities**.

- **Strong AI** vs **Weak AI**: **Strong AI** refers to the concept of machines that can perform **any intellectual task** a human can do. In contrast, **Weak AI** represents systems designed to excel at a **specific tasks**, narrowly defined.
- **Machine Learning**: Machine learning is a **subset of AI** that uses **statistical methods** to enable machines to improve at tasks with **experience**. This improvement is based on data input and can occur in a supervised (known output) or unsupervised (unknown output) manner.
- **Deep Learning**: A more complex form of machine learning, deep learning utilizes **neural networks** with many layers (consequently "deep") to process data, make connections and weigh inputs to **optimize results**.

These definitions collectively capture the core concept of AI as a discipline that seeks to **create machines** capable of **mimicking**, to varying extents, the cognitive abilities traditionally associated with **human intelligence**.

1.2. Brief History of AI

In a overview, considering that the field of AI is vast with many sub-fields and detailed history, we may consider as main historical periods (adapted based on Anyoha, 2017):

- **Conceptualization and Initial Challenges (1940s-1950s):**
  - The concept of AI was popularized by **science fiction** and **cultural narratives**. Notably, British polymath **Alan Turing** "explored the mathematical possibility of AI" in his 1950 paper, 'Computing Machinery and Intelligence'" (Anyoha, 2017). Other works came after the formal field of AI began to take shape but they played an important role in shaping public perceptions and understanding of AI concepts. Prominent works of science fiction as these have played a role in **shaping the collective understanding** of what AI could potentially be:
    - "**I, Robot**", by **Isaac Asimov** (1950), which includes stories published separately between 1940 and 1950.
    - "**Do Androids Dream of Electric Sheep?**" by **Philip K. Dick** (1968).
  - A significant point in AI's conceptualization in popular culture was Isaac Asimov's "I, Robot" (1950), in which he presented the "Three Laws of Robotics" which provided a framework of ethical guidelines for AI behavior, and have since been influential in shaping discourse on AI ethics and safety:

    «*A robot may not injure a human being or, through inaction, allow a human being to come to harm.*

    A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.»

- During this time, computers lacked the ability to store commands and were very **expensive**. This limited the ability to develop AI systems. However, the **potential** of machine intelligence was **recognized**.

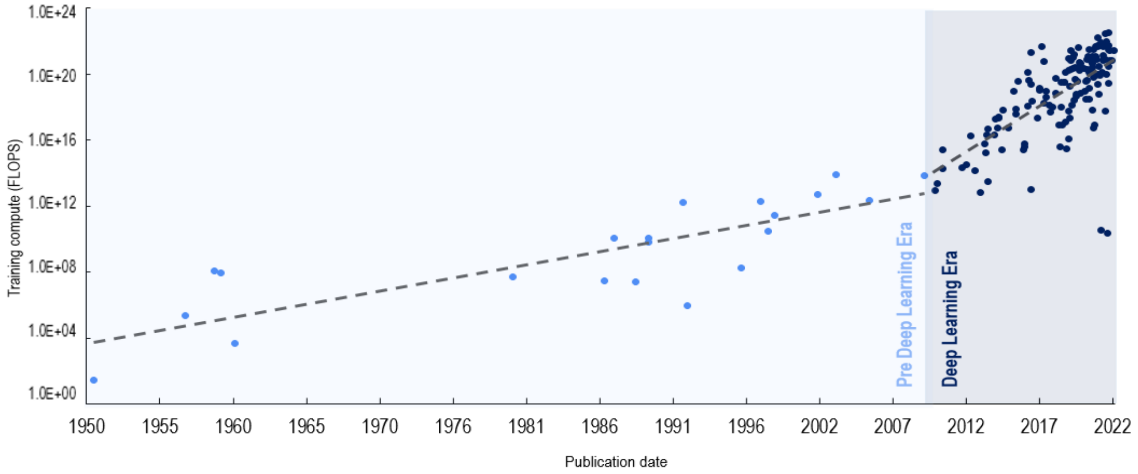
- **The Dartmouth Conference (1956):** The "Dartmouth Summer Research Project on Artificial Intelligence", hosted by John McCarthy, Marvin Minsky, Nathaniel Rochester and Claude Shannon, is considered a significant event in AI history. The **Dartmouth Conference** was significant in AI history because it is often considered the **birthplace of AI as a field of study**. Despite lack of agreement on standard methods, there was consensus that **AI was achievable**, catalysing the next two decades of AI research (McCarthy et al., 1955).
- **The perceptron (1958):** Developed by Frank Rosenblatt, the perceptron was the first model that could be trained using a learning algorithm and highlighted the possibility of building a brain-like machine – "**A machine which senses, recognizes, remembers, and responds like the human mind**" (Rosenblatt, 1958a; Rosenblatt, 1958b). Despite its **simplicity**, the perceptron was a **major milestone** in AI because it demonstrated the potential of training an algorithm to learn from data.
- **AI Flourishing and Subsequent Setbacks (1960s-1970s):** During this time, computers became **faster, cheaper and more accessible** and **machine learning algorithms improved**, but AI was mainly used for problem-solving and pattern recognition. However, despite initial successes, it became evident that the ultimate objectives, such as mastering natural language processing, abstract reasoning and self-awareness, were **quite remote**. The **insufficient computational capabilities** at the time resulted in reduced enthusiasm and financial support, causing a slowdown in AI research.
- **Reignition of AI (1980s):** The AI field was revived due to an expansion of the **algorithmic toolkit** and **increased funding**. During this era, there was a surge in popularity for deep learning methodologies and expert systems. Nonetheless, the lofty aspirations often **fell short of realization**, which consequently triggered another phase of waning enthusiasm towards AI (Klondike, n.d.).
- **AI Thriving (1990s-2000s):** In the absence of public hype, many **landmark goals** of AI were achieved. **IBM's Deep Blue** defeated Garry Kasparov[2] in 1997[3] and **speech recognition software** was implemented on **Windows**. This period demonstrated that machines could handle a wide range of problems.

[2] World chess champion between 1985 and 2000.

[3] Later, in 2017, Google's Alpha Go defeated Chinese Go champion, Ke Jie, highlighting again the potential of AI in decision-making processes.

- **Increase in Computational Power (2010s-present):** With the **increase in computational power**, advancements in AI have accelerated. This period saw the development of **deep learning** (which involves training large neural networks on vast amounts of data) and **AI models capable** of complex tasks such as recognizing images and understanding human language.
- **The boom (2020s):** Today, AI is a **rapidly growing field** with applications in a wide range of industries. Researchers are developing new techniques for training machines to perform **complex tasks**. The boom of AI in the 2020s has seen many breakthroughs in the field, namely **generative AI** (e.g., Chat GPT, Bing or Bard), capable of understanding and generating information.

Estimated compute used for training milestone ML systems between 1952-2022



Source: OECD, 2023b

The boom of AI in the **2020s** has seen many **breakthroughs in the field**, with advancements becoming increasingly integrated into various industries and applications. From its **conceptual origin** to the **rapid development** witnessed in recent years, AI's journey is a clear demonstration of **technological evolution**. As AI continues to grow and evolve, underlining the necessity to **understand the range and intensity** of AI's current influence in our society.

Finally, it is important to recall **Moore's Law**, a prediction made in 1965 by Gordon Moore, co-founder of Intel, where he considered that that **computer processing power** had **doubled approximately yearly** since the invention of the integrated circuit and predicted that this trend would continue into the foreseeable future (Gordon Moore, 1965). In 1975, he **revised** his prediction to state that the **doubling would occur every two years** (Gordon Moore, 1975). Essentially, Moore's Law suggests that **computer processing power would double approximately every two years, leading to an exponential increase in computational power over time**. There is significant debate around the continued

applicability of Moore's Law, as the physical limits of silicon-based semiconductor technology may be approaching but **new advances in computing paradigms could redefine how the law continues to apply in the future**.

1.3. Importance and Prevalence of AI

AI is increasingly becoming a **critical component of the global digital economy** due to its vast potential to transform industries and create economic value. The prevalence of AI is evident across a wide array of sectors, driven by the exponential growth of **digital data**, advances in **computing power and storage** and breakthroughs in **machine learning algorithms**.

Several key factors are driving the adoption of AI across various industries:

- **Increased Data Volume:** With the proliferation of internet services and connected devices, there is an explosion in the **amount of data generated every day**. AI can process and analyse these massive datasets quickly and efficiently, providing businesses with valuable **insights** that can inform **decision-making**.
- **Improved Computing Power:** Advances in computing technology, such as the development of **powerful processors** and the availability of **cloud computing services**, made it feasible to run complex AI algorithms that require significant computational **resources**.
- **Advancements in Machine Learning:** The development of sophisticated **machine learning algorithms**, especially **deep learning**, made it possible for AI systems to **learn** from data, **recognize** patterns and **make** predictions or decisions with increasing accuracy.
- **Industry Digitization:** The ongoing digital transformation of various **industries** has created a demand for **AI-powered solutions**. Businesses are leveraging AI to automate tasks, enhance efficiency, improve customer experiences and gain a competitive edge.
- **Need for Improved Operational Efficiency:** AI can help businesses **automate** repetitive tasks, optimize business operations and make more accurate forecasts, leading to significant **cost savings** and **improved operational efficiency**.
- **Demand for Personalized Services:** In industries like **healthcare**, **retail** and **entertainment**, there is a growing demand for **personalized services**. AI can analyse individual user data to provide personalized recommendations, services and experiences.
- **Regulatory Support:** In some cases, regulatory support and incentives are encouraging the adoption of AI. For example, **governments** are increasingly recognizing the **potential of AI** in sectors like **healthcare** and **transportation** and are implementing **policies** to encourage its adoption.

The ability of AI to analyse and interpret complex patterns from large data sets is unlocking **opportunities in industries** such as healthcare, transportation, energy and finance, among others. For instance, in **healthcare**, AI is enabling earlier and more accurate **disease detection, personalized medicine and better patient care** (Kumar et al., 2023; Mirbabaie et al., 2021; Technische Universität Dresden, 2021). In **transportation**, AI-powered autonomous vehicles are paving the way for **safer and more efficient travel** (Conde et al., 2019). In the **energy sector**, AI is helping to **optimize** the **generation** and consumption of power, enhancing energy **efficiency** and facilitating the integration of **renewable sources** (Makala and Bakovic, 2020; Mehlum et al., 2021). In **finance**, AI is transforming the way **risk is assessed**, leading to more accurate credit scoring and fraud detection (Basrai and Ali, 2021).

AI is also playing an increasingly important role in the **public sector**, improving **service** delivery, enhancing public **security** and supporting **policymaking** (Brooks, 2021; Noordt and Misuraca, 2022; Zuiderwijk et al., 2021). For instance, AI is being used to predict and manage **traffic in real-time**, making cities smarter and more liveable. In the area of **public security**, AI technologies such as facial recognition and predictive analytics are helping to **prevent crime and enhance safety**. In **policymaking**, AI tools are enabling more **informed decision-making** by providing insights from large volumes of data.

Despite these benefits, the growing importance and prevalence of AI also raise important **ethical, security and socio-economic challenges** that need to be addressed. These include concerns about privacy, fairness, transparency, job displacement due to automation and the security implications of AI in areas such as cyber-security and autonomous weapons.

While the importance and prevalence of AI are undeniable, it is crucial to harness its **benefits** in a manner that **aligns** with **societal values and norms** and promotes inclusive and sustainable development. This will require a concerted effort from all stakeholders, including governments, businesses, civil society and the research community.

As we continue to delve into the realm of AI, it becomes increasingly clear that this technology **permeates every facet of our lives**, transforming industries, reshaping economies and redefining societal structures. We have now begun to understand how AI has become an integral part of our global landscape and the potential it holds for future growth and development. This vast potential, though, is **not merely abstract or theoretical**; it is being realized in tangible ways across various sectors, through the **development of innovative applications**.

In the next chapter, we will explore some of the **ways AI is being utilized in different sectors**, focusing on unique applications and innovations that not only demonstrate the **capabilities** of AI but also hint at the **transformative changes** yet to come. This forthcoming exploration of AI applications, from healthcare to smart cities to fintech, will provide an in-depth look into how AI continues to **reshape our economic, social and even environmental landscapes**.

"It is change, continuing change, inevitable change, that is the dominant factor in society today. No sensible decision can be made any longer without taking into account not only the world as it is, but the world as it will be."

Isaac Asimov, "I, Robot"

2. AI Applications and Innovations

The rise of AI created new opportunities, leading to a broad range of **applications and innovations** that are transforming various **sectors**. AI's prevalence lies in its ability to **mimic** human cognition, **learn** from data, **generate** various types of contents and **improve** performance over time. It has become a significant **driver of change**, revolutionizing the way businesses operate, how public services are delivered, how research is conducted and even how personal activities are carried out. AI's impact **extents across sectors** like healthcare, education, transportation, finance or e-government, with each field witnessing the emergence of novel AI applications that enhance **efficiency, accuracy and productivity**.

As we move forward, AI is anticipated to **transcend its current functions**, addressing more complex problems and offering unprecedented solutions. These innovative applications extend beyond traditional sectors to areas like climate change modelling, early detection of pandemics, quantum computing or even space exploration. The innovation also reaches the heart of our societies, with AI transforming even education, social interactions and the way we perceive ethics and law.

This section will delve into some of these emerging, applications and innovations of AI that are shaping our world today and that promise to further revolutionize our world.

2.1. Healthcare

This segment illustrates how AI has emerged as a **transformative force** in healthcare, redefining diagnostics, patient care, and research.

According to Marr (2022), these are the top five **healthcare trends** in 2023:

- **Healthcare:** AI has an extensive role in healthcare, from drug discovery and medical imagery analysis to treating neurological disorders and automating clerical/administrative work. It aids in predicting clinical trial outcomes, detecting diseases and managing medical records, among other applications.
- **Remote Healthcare:** AI plays a pivotal role in the growth of remote healthcare, including home-based care, telemedicine and virtual hospital wards. AI technologies enhance the effectiveness and efficiency of these services.

- **Retail Healthcare:** Retail giants are integrating AI into their healthcare services, including medical check-ups. AI streamlines these services, making them more accessible and convenient for customers.
- **Wearable Medical Devices:** AI and machine learning capabilities are incorporated into wearable devices, from simple vital sign trackers to sophisticated smartwatches and smart textiles, assisting in comprehensive health tracking and condition prediction.
- **Personalized Healthcare:** Personalized healthcare uses AI and machine learning to tailor treatments based on individual factors, thus giving patients more control over their healthcare planning and delivery.

Secinaro et al. (2021) also refer that "these technologies can also contribute to **optimizing logistics processes** in health services and allowing a **better allocation of resources**".

Finally, Rong et al. (2020) consider that, in addition, AI can make major contributions in the direction of healthcare becoming more "**personal, predictive, preventative and participatory**".

2.2. Robotics and Automation

We, now, explore how AI is the driving force behind the **automation** revolution, reshaping industries, labour markets and our everyday lives with the advent of sophisticated **robots**.

According to George (2022), these are the top **five trends in AI Robotics** in 2022:

- **Industrial Robots:** AI integration is revolutionizing the manufacturing sector by enhancing the accuracy and performance of industrial robots. These advancements are particularly influential within the food and beverage, automotive and pharmaceutical industries, where there is a high demand for such technology.
- **Collaborative Robots or Cobots:** AI-enhanced cobots work symbiotically with humans to increase productivity. They can learn and improve over time, making them particularly effective in industries such as call centres and healthcare. In the latter, cobots can perform non-clinical tasks like restocking medical supplies.
- **Retail Robotics:** The retail industry has adopted AI-powered delivery robots, especially during the pandemic, for contactless delivery. Other applications of AI in retail include inventory management, development of cashier-free shopping experiences and quality control.
- **Robots as a Service:** Robots as a Service offer smaller companies the opportunity to leverage cloud-based robotic process automation solutions. This service model provides the benefits of scalability and cost reduction and is particularly useful when there is lack of human labour or when it is too expensive.
- **Robots in Healthcare:** The healthcare industry, as previously referred, is leveraging AI-powered robotics for various tasks including appointment scheduling, medical billing and claim submission. Wearable AI devices "can help detect early

warning signs of diseases and help doctors monitor patients". Furthermore, AI robots are used in surgical procedures, medical research and training sessions.

Ribeiro et al. (2021) also discusses the advantages of using robotic process automation and AI algorithms together to "improve the accuracy and execution of **robotic process automation processes** in the **extraction of information**".

Lastly, an article by Macrorie et al. (2019) argues on how "new generation robotics and automation (…) represent a potentially **powerful new mode of urban restructuring**".

2.3. Sustainability

Turning our focus to **sustainability**, we explore how AI technologies are integral to enabling companies and societies to adopt more sustainable practices, encouraging greener initiatives and aiding in the journey towards a more **environmentally-friendly future**.

According to Sanu (2019), this are **five examples**:

- **Energy Efficiency in Data Centres:** Google and DeepMind developed an AI system that optimizes data centre operations, reducing energy required for cooling by 40%. This innovative use of AI contributes significantly to energy conservation and carbon emission reduction.
- **Sustainable Fishing:** Global Fishing Watch, a joint project by Google, SkyTruth and Oceana, uses machine learning to detect and highlight potential overfishing. This technology promotes sustainable fishing practices and safeguards the health of global fish stocks.
- **Agriculture:** AI is transforming agriculture through platforms like aWhere and Plantix. They utilize machine learning and image recognition to analyse crops, forecast weather and identify plant health issues. This leads to higher crop yields and more efficient resource use.
- **Water Conservation:** WINT uses AI to identify water leaks in buildings, helping to prevent property damage and conserve water. This technology has proved to be precise and cost-effective, leading to substantial water and financial savings.
- **Reducing Food Waste:** Winnow employs computer vision to track food waste in kitchens, leading to waste reduction and cost savings. The environmental impact of this technology is significant, offering substantial CO2 savings.

Meinecke (2018) discusses the evolving role of AI in addressing **environmental issues** while also **acknowledging the risks** that come with the technology:

- AI has the potential to transform **manufacturing** and **reduce its environmental impact**. For instance, AI could assist in developing new, **eco-friendly materials** to replace environmentally harmful ones like plastic. The Open Quantum Materials Database uses AI and databases to explore new materials that could a**ddress energy challenges**.

- In terms of the **risks**, the increasing demand for electronic products, which often go together with AI development, leads to **more intensive use of raw materials** and the extraction may cause environmental damage. Moreover, the production of **plastics for products and packaging**, as well as the **accumulation of e-waste**, pose additional environmental challenges. The article also discusses the energy concerns related to AI. The global population's **growing demand for electricity** couples with the increasing adoption of technology - more data to be processed requires more energy.

2.4. Automotive Industry

There are also several examples of innovative AI applications in the **automotive industry**.

According to Gonzalez (2022), these are **three ways AI is impacting the automotive industry**:

- **Accident Prevention:** AI is enhancing safety measures in vehicles. An example is Tesla's AI-enabled interior camera, which monitors driver alertness to prevent accidents, utilizing neural networks to analyse and interpret road conditions.
- **Personalized Vehicles:** Porsche uses AI for a personalized vehicle experience. Their machine learning system, "Recommendation Engine," suggests vehicle configurations based on individual preferences, boasting over 90% accuracy in its recommendations.
- **In-Car Assistance:** AI-powered voice assistants are becoming prevalent in cars. Mercedes Benz's infotainment system, MBUX, leads in this area, responding to voice commands (much like Apple's Siri).

The platform Market Trends (2021) highlights **other AI Innovations that are transforming the automobile industry**, including the following:

- **Autonomous Vehicles:** Self-driving vehicles, capable of sensing their environment and operating without a human driver, provide mobility independence, especially beneficial for the elderly.
- **Collaborative Robots:** "Cobots" in the automotive industry work alongside human employees, improving efficiency and accuracy in tasks like machine loading, inspection and assembly.
- **Driver Monitoring System:** AI innovations include driver monitoring systems that use hi-tech infrared cameras to track driver's eye movements, alerting them during drowsiness or distraction to prevent road accidents.
- **AI Cameras:** Vehicles equipped with AI cameras enhance road safety by using AI for image and video recognition.

Regarding **autonomous driving**, McEvoy (2023) refers that **Level 3 autonomy** has been achieved and this refers to cars that can "**drive with conditional automation**". This means that the "vehicle can perform most driving tasks, but the **driver retains full responsibility**"

and "human override is still required". **Level 4 autonomy**, on the other hand, refers to "**high automotive automation"**' and "requires **very little human interaction**". However, it is only applicable under specific circumstances, such as certain weather conditions and routes. According to the same author, the Level 4 autonomy still faces challenges that include **safety, infrastructure and sustainability**. Level 4 autonomous vehicles promise improved safety by reducing human error, but building public **trust** and **securing** these vehicles against cyberattacks pose challenges. Additionally, the **infrastructure** for these vehicles isn't fully defined yet and will require substantial **investments and regulatory updates**. Finally, while autonomy may reduce congestion and inefficient driving styles, thus conserving energy, it **might increase overall mileage** due to more drivers and longer commutes, which could impact sustainability goals.

2.5. Smart Cities

The adoption of AI in Smart Cities is already a reality and AI is being **used in the smart city concept in many ways**.

Herath and Mittal (2022) reviewed 133 articles from 2014 to 2021 and found that AI adoption in smart cities is being used particularly in the "**healthcare (23% impact), mobility (19% impact), privacy and security (11% impact), and energy sectors (10% impact)**".

We may highlight some of the **examples of innovative applications** of AI in Smart Cities provided by Buttice (2022):

- **Smart Energy Metering:** Utilization of AI to optimize energy consumption, leading to increased efficiency and cost savings.
- **IoT-Enabled Park Benches:** IoT devices installed on park benches, collecting environmental data and visitor feedback for urban planning.
- **Augmenting Workforce Knowledge and Skills:** AI technologies transferring veteran employees' expertise to newer generations, fostering skills continuity.
- **Enhanced Business Chatbots:** AI chatbots reshaping consumer-brand communication dynamics, providing intuitive and responsive customer interactions.
- **Smart Security Cameras:** AI-enabled security systems detecting potential threats in real-time, promoting safer urban environments.
- **AI-Powered Parking Systems:** AI-infused parking solutions offering real-time updates on availability, streamlining urban parking experiences.
- **Air Pollution Mitigation:** AI tools monitoring and predicting air quality issues, contributing to environmental sustainability.
- **Advanced Traffic Management:** AI technologies reducing traffic congestion and greenhouse gas emissions, fostering greener and smoother travel.
- **Adaptable Work Environments:** AI systems in workplaces that adjust environmental parameters, improving employees' well-being.

- **Intelligent Power Plants:** AI enhancing the efficiency of power plants, optimizing power output in response to environmental conditions.
- **Precise Predictions and Projections:** AI providing accurate forecasts for alternative energy products' adoption, aiding strategic decision-making.
- **Robots Powered by Cloud AI:** Advanced robotic systems leveraging cloud-hosted AI, fostering flexible and collaborative improvements.

Zamponi and Barbierato (2022) argue that the **vast amount of information** collected by electronic devices, alongside with the **algorithms** used to analyse this data, should be considered as **foundational pillars** of smart cities. These authors also emphasize the **crucial role of energy** in smart cities and the necessity of algorithms to "**plan and forecast the energy consumption of smart cities**". AI can further enhance the innovative value and efficiency of smart grids, electric vehicles and smart buildings. The authors highlight **governance** as a fundamental asset in smart cities, as it can "**improve the quality of life of the citizens, enhance leadership, protect the environment, and support local economies**". However, they also highlight several **challenges** associated with implementing AI in smart cities. These challenges include the **energy consumption** and **environmental impact** of data processing, **privacy concerns**, **potential job losses** due to automation, **bias** in datasets used to train algorithms, **ethical concerns** around decision-making by algorithms and **legal issues** related to the lack of a formal definition of AI as a legal entity, as we will further discuss in chapter 4. Despite these challenges, the authors suggest that these "**can be mitigated** by the definition of proper **polices**".

2.6. Fintech

Innovative AI applications are also being used in **Fintech**.

The World Bank Group (2018) considers that **fintech** is "**transforming the financial sector landscape** rapidly and is blurring the boundaries of both financial firms and the financial sector".

Gomber et al. (2018) consider that AI is being used in fintech to **improve customer service**, **reduce costs** and **increase efficiency**, also providing examples of innovative AI applications in fintech such as **robot-advisors**.

According to Tang (2023), AI & Machine Learning technologies are revolutionizing many areas in Fintech like "**banking**, **payments**, **investments**, **risk management** and more" by **automating processes** like "loan origination or fraud protection" and "providing more accurate insights into **customer behaviour**". This is helping businesses "**reduce costs** associated with manual labor while simultaneously **increasing overall performance, accuracy and efficiency**".

According to Bharadwaj (2018), these are **some applications of AI in Fintech**:

- **Automate the creation of reports:** Based in Paris, Yseop provides a software solution named Yseop Compose. This tool harnesses natural language generation

to automate the creation of reports for banking and financial institutions. Users interact with a bespoke dashboard, inputting business metrics which the software transforms into digestible reports, aided by contextual insights from experts.

- **Generate narrative reports from structured data:** Narrative Science, a Chicago-based company, developed a software called Quill, designed to "generate narrative reports from structured data, such as sales records". By integrating with existing business processes, Quill uses natural language generation to create reports that can be easily understood by non-technical staff.
- **Predict portfolio performance:** Operating out of Washington, Kavout presented Kai Score, a solution that predicts portfolio performance for investment and equity firms by leveraging "predictive analytics, big data and machine learning". The software sifts through vast amounts of data to identify financial market patterns and predict asset performance. Users receive predictive insights for their preferred stocks, which indicates the likelihood of the "stock outperforming its historical trends".

2.7. E-Government

Innovative AI applications are also **in place in the e-Government** sector.

According to a report by Deloitte (2023), AI has already been making a **significant impact** in the e-Government sector, **revolutionizing** numerous aspects of public administration and services. However, the potential of AI **extends beyond** what has been implemented so far, promising to bring further advancements in this sector.

The following examples provided by Deloitte (2023) are divided into two categories: current and implementations and future perspectives.

- **Current Implementations**
  - **Benefits Administration:** The deployment of AI has enhanced the quality and efficiency of service delivery by tailoring service recommendations and improving customer engagement. It has also transformed the workplace experience for employees and diminished their workload.
  - **Claims Processing Back Office Automation:** Robotic process automation, natural language processing and computer vision technologies have been harnessed by governmental bodies to convert physical documents into digital format and expedite their processing time.
  - **Population Risk Support:** Advanced AI systems, in collaboration with human teams, are employed to forecast risks associated with housing and food instability, substance dependencies and mental health incidents. This aids in the formulation of public policies aimed at elevating the living standards of citizens.

- **Health and Environmental Predictions:** AI is leveraged by governments to detect patterns and devise solutions for public health and climate change issues by understanding their potential impacts.
- **Biomedical Data Science:** The utility of AI algorithms in analysing extensive biomedical data, including genomics, imaging and clinical data, has revolutionized the speed at which new methods for disease prevention, diagnosis and treatment are discovered.

- **Future Perspectives**
  - **Video Surveillance Predictions:** AI combined with computer vision technology may be adopted in video surveillance systems to identify potential security threats.
  - **Agent-based Simulations to Refine Military Strategy:** Deep learning techniques may be used to create real-time simulations of tactical operations, thereby refining military strategy.
  - **Civil Asset and Infrastructure Management:** Governments may employ AI to oversee and maintain urban infrastructure and assets to ensure their safe and efficient operation.
  - **Legal Outcome Predictions:** Machine learning and deep learning may be applied to scrutinize years of legal precedents and numerous past cases to predict the outcomes of future cases, thereby accelerating resolutions in legal systems.
  - **Education Tech:** AI may be instrumental in personalizing the education experience to cater to individual learners' needs and capabilities.

Also according to Dilmegani (2023), AI has numerous applications in the public sector including **enhancing government operations** by streamlining tasks for increased efficiency, **improving public services** like autonomous transportation and personalized education, and facilitating **data-driven decision making** through accurate analysis of collected data.

Dilmegani (2023) also highlights some of the specific AI applications in government sectors, including:

- **Government services:** AI can help in identifying fraudulent welfare claims, track disease spreads, triage patients, handle citizens' health-related queries, predict crimes, optimize police presence, enable surveillance and autonomous drones.
- **Transportation:** Autonomous shuttles can provide a flexible solution to transport people, while AI can also be used to monitor social media to identify incidents like traffic congestion due to road accidents.
- **Education:** AI can support personalized education and help mark exam papers efficiently, providing immediate feedback to students.
- **Emergency:** AI can help classify emergency calls based on urgency and predict potential wildfires.

- **Public relations:** AI-powered chatbots can improve customer service by performing a wide range of tasks.

It is important to highlight the results of a report from the Joint Research Centre of the European Commission, authored by Misuraca and Noordt (2020), which emphasizes the **potential of AI in reshaping public services and policy mechanisms for improved quality and citizen engagement**. Despite this potential, AI adoption in government is currently **limited** and tangible socio-economic impacts are not well-documented due to sparse research in the sector. The report suggests AI governance should extend from existing regulatory tools and, although current guidelines seem sufficient, ongoing evidence gathering may necessitate revisions. It underscores the **need for human-centric AI, innovative public procurement and continued research on AI implementation in public services**. Furthermore, the report encourages **learning through experimental projects**, emphasizing the potential benefits of unique funding programs for AI projects in government and GovTech solutions development.

2.8. Sustainable Development Goals

As we delve deeper into the profound impact of AI, it is also important to consider its **potential contribution to the SDG**, established by the United Nations (2015).

These 17 interlinked goals serve as a blueprint for achieving a **more sustainable future for all**, addressing global challenges like **poverty**, **inequality** and **climate change**.

With its diverse applications and transformative power, some of which referred previously in this chapter, AI can play a crucial role in **accelerating our progress** towards achieving these goals (United Nations, 2015):

- **Poverty Alleviation and Zero Hunger (SDG 1 and 2):** AI can be used in agriculture to improve crop yields, predict weather patterns and identify potential threats like pests or diseases, thereby increasing food security and reducing poverty (Fraisse, 2022).
- **Quality Education (SDG 4):** AI can support personalized learning systems that adapt to students' individual needs, improving the quality of education (Bhutoria, 2022).
- **Clean Energy (SDG 7):** AI can optimize energy use in industries and homes, contributing to energy efficiency and promoting the use of renewable energy (Abdallat, 2020).
- **Climate Action (SDG 13):** AI can be used in climate modelling and prediction, helping to understand and mitigate the impacts of climate change (Chantry et al., 2021).
- **Life Below Water and Life on Land (SDG 14 and 15):** AI can assist in monitoring and protecting biodiversity, both in marine and terrestrial ecosystems (Green, 2022).

From addressing poverty and hunger to promoting quality education, clean energy, and biodiversity, AI holds significant **potential in catalysing progress towards the SDG**. However, it is essential to bear in mind that the application of AI for sustainability and development is a collective responsibility, demanding **concerted efforts from governments, academia, industry and society**. Through **careful and ethical** application, AI can indeed be a powerful tool in our quest for a more sustainable and equitable world. As we continue our exploration of AI's possibilities, let us strive to leverage its potential for the greater good, **ensuring our way towards sustainable development that leaves no one behind**.

"The fusion of machine capability and human consciousness is a powerful combination."
Arthur C. Clarke, "2001: A Space Odyssey"

3. The Role of AI in the Digital Economy

AI has been a **transformative force in the digital economy**. As referred in chapter 1, AI enables **problem-solving** and perform **tasks** commonly associated with **intelligent beings**, ranging from basic pattern recognition to more complex activities such as **problem-solving** and **decision-making**.

AI plays a **decisive role** in today's digital economy. AI's role in the digital economy is **not limited to simple task automation**. AI systems can make decisions that typically require human expertise, helping people "anticipate problems or deal with issues as they come up" and this ability allows AI systems to "operate in an **intentional, intelligent and, adaptive manner**", making them an invaluable asset in a wide range of industries (West and Allen, 2018).

As previously referred, it **powers various technologies** that form the backbone of the modern internet era and influences sectors such as finance, healthcare or manufacturing. Current AI trends include **chatbots**, **generative AI** and **mobile applications**.

AI is significantly influencing the digital economy, particularly in **data analysis**. Companies can utilize AI to scrutinize **vast data sets** rapidly and precisely, thereby yielding critical insights and facilitating informed **decision-making**. AI's predictive analytics can determine trends, assisting in forecasting future occurrences, which aids in **strategic planning**.

AI's pivotal role in automating routine tasks **enhances operational efficiency** , leading to time and resource savings, elevating productivity and profitability and reducing human errors across a variety of sectors.

Customer service has been revolutionized by AI through **chatbots and virtual assistants** that interact with customers in real time, provide immediate responses and offer personalized service through customer data analysis.

In **cybersecurity**, AI, through machine learning algorithms, identifies potential threats, notifying security teams, which **mitigates the risk of data breaches and cyber-attacks**.

Lastly, AI **fosters innovation** in the digital economy by accelerating prototyping and providing predictive models, which aids businesses in developing new products and swiftly adapting to market shifts.

In this chapter, we will explore the **multi-faceted economic impacts of AI**, from overall **market trends** and **future projections** to the specific **positioning of the European Union within the global AI landscape**. We will also consider the **opportunities AI presents for the Portuguese economy**, given its transformative potential across various sectors.

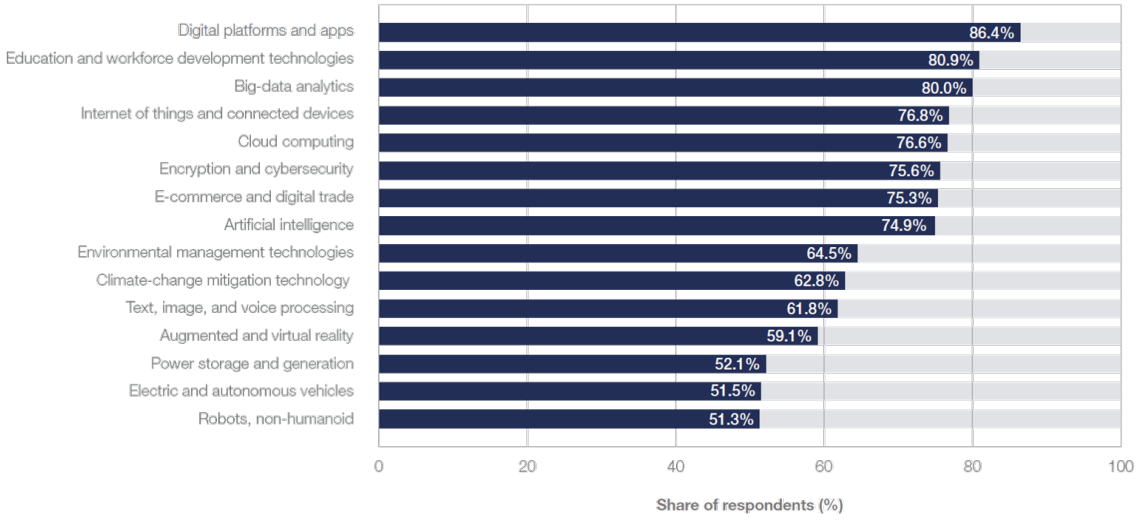
3.1. Economic Impacts, Market Trends and Projections

According to Osório de Barros (2021), AI "is a fast-growing technology that enables **public and private institutions** (not necessarily technology enterprises) to use **data-driven decision making** and is gaining importance in many areas like **industrial processes logistics, facility management, sales, digital marketing or human resources**".

The economic potential of AI is **significant** and it is expected that many **industries will adopt AI** within their business structures in the coming years. In fact, Next Move Strategy Consulting (2023) considers that the AI revolution is **not confined to a specific sector**, as a wide range of industries from logistics to marketing, manufacturing, research, analytics and beyond are **expected to integrate AI technologies** into their operational frameworks.

According to the World Economic Forum (2023), AI may be **integrated** until 2027 by almost **75% of the companies surveyed**.

Technology adoption, 2023-2027



Note: Technologies ranked by the share of organizations surveyed who are likely or highly likely to adopt this technology over the next 5 years

Source: World Economic Forum, 2023

AI has the potential to generate **significant economic benefits across various sectors** and different estimates, although not comparable, can give as the idea of the significative economic impact:

- Chui et al. (2023) provide some estimates ion the impact of generative AI:
  - Generative AI could add between **$2.6 trillion and $4.4 trillion annually to the global economy** across the 63 use cases analysed, potentially increasing the impact of all artificial intelligence by 15 to 40 percent;
  - Around 75 percent of the value from generative AI falls across four areas: **customer operations, marketing and sales, software engineering and R&D**;

  - Generative AI is expected to significantly impact all industry sectors with **banking, high tech and life sciences** standing to see the biggest impact in terms of their revenues.
- According to a forecast from the International Data Corporation (2023):
  - **Global spending on AI will hit $154 billion in 2023**, marking a 26.9% rise from 2022;
  - With AI being incorporated into various products, **spending on AI-centric systems** is predicted to show a compound **annual growth rate (CAGR) of 27.0%** between 2022 and 2026, crossing the **$300 billion** mark in 2026;
  - Companies lagging in AI adoption risk falling behind;
    - By 2023, over a quarter of all AI expenditures will be attributable to three principal AI applications: (i) **Enhanced Customer Service Agents**, (ii) **Sales Process Advice and Amplification** and (iii) **Program Advisors and Recommendation Systems**;
    - In 2023 and subsequent years, the heaviest investment in AI will originate from the **Banking and Retail sectors, with Professional Services, Discrete and Process Manufacturing following behind**;
    - The fastest growth in AI spending is expected from the Media industry, with a five-year **CAGR of 30.2%**.
- Considering a report issued by Next Move Strategy Consulting (2023) AI market will assist to a **robust expansion over the next decade**, predicting that the market value will **grow about twenty times from 2021 to 2030** (from close to 100 billion dollars to near **two trillion dollars**), a **CAGR of 32.9%**.
- The European Parliamentary Research Service (2019) also cites a study by Accenture that forecasts that, by 2035, AI could **double annual global economic growth rates**;
- According to a report by McKinsey Global Institute (Chui et al., 2018), AI has the potential to create **between $3.5 trillion and $5.8 trillion** in annual value across **nine business functions** in nineteen industries;
- Another report by PwC (2017) estimates that AI could contribute up to **$15.7 trillion to the global economy by 2030**, representing a **14% boost to global GDP**. This growth is expected to come from **productivity gains**, as AI automates routine tasks and frees up workers to **focus on more complex tasks** and from consumption side-effects, and while AI leads to the creation of **new products and services** that transform the consumer experience.
- A report by Accenture (2017) estimates that AI could add **$14 trillion to the global economy by 2035**.

While the specific figures vary, the overarching conclusion from these different estimates is clear: **AI is having a significant economic impact**. According to forecasts from various reputable institutions, the AI market is projected to **grow exponentially**, potentially contributing trillions of dollars to the global economy by 2030/2035. Despite the disparities in figures, the **consensus points towards the enormous economic potential** of AI. Companies that **lag in adopting AI risk falling behind**, indicating that embracing this technology is not merely beneficial but may be **essential for economic survival and competitiveness**.

Additionally, it is important to highlight AI's **importance in the current digital economy** considering that:

- "It can **increase the efficiency** with which things are done and vastly improve the decision-making process by analysing large amounts of data" (European Parliamentary Research Service, 2019);
- Since AI is "unconstrained by humans' cognitive limitations and inflexibility" (Hang and Chen, 2022), it is **crucial for firms' success in digital economy**;
- AI "is **shaping an increasing range of sectors**" (Vinuesa et al., 2020);
- AI is expected to **affect global productivity** (Acemoglu and Restrepo, 2018):
    - The task-based framework focuses on the **impact of automation on labour displacement**, where machines and AI substitute human labour, leading to a decline in labour demand and wages.
    - However, a **counteracting productivity effect** arises from the cost efficiencies that automation brings, boosting the need for labour in **tasks that are not automated**. This effect in the productivity is further amplified by **increased capital accumulation** and the **enhancement of existing automated processes**, which also raises **labour demand**.

In conclusion, AI has already started to **shape the digital economy** and its influence is set to **grow exponentially**. Based on the data from various reports, AI is forecasted to make an **enormous economic impact** in the coming decade. These gains are expected to be derived from a **wide range of sectors** and the most considerable growth is predicted in industries like banking, retail, and professional services. It is also clear that AI will play a pivotal role in future **productivity increases** and firms that adopt AI technologies are likely to gain a **competitive edge** in the rapidly evolving digital economy.

While it is necessary to acknowledge the **potential for labour displacement** due to AI automation, it is also important to consider the **counterbalancing productivity gains** and the new roles that will emerge from these technological advancements. The transformative power of AI is not limited to simple task automation but extends to complex decision-making processes, **enhancing efficiency, reducing human error and potentially revolutionizing the way we work and live**.

These economic impacts and market trends reinforce the importance of not only adopting AI but also **integrating it strategically across different sectors**. The economic landscape is rapidly shifting under the influence of AI and understanding this evolution will be crucial for **policymakers, businesses and individuals** alike.

3.2. European Union's Place in the Global AI Market

Europe has a critical role to play in the future of the global AI market. Several factors contribute to Europe's unique positioning, including the region's **focus on ethical AI**, its **robust talent pool** and ongoing **initiatives for R&D in AI**.

The EU has been **active in creating a regulatory framework that focuses on ethical considerations in AI**. The proposed AI regulations by the European Commission (2021a) highlights transparency, accountability and human oversight, placing Europe at the forefront of setting **global ethical standards for AI**. These regulations are expected to **influence global AI market** trends and drive the development of more **trustworthy AI systems**.

Europe's rich **talent pool in AI** and related fields, boosted by strong educational systems and institutions, is another asset (Castro et al., 2019). The EU takes the second place in terms of the number of **AI-specialized master's programs**, produces **16% of the global research papers** and countries like Germany, France and Italy have shown **high AI skill penetration rates**, indicating the presence of AI skills among professionals (Digis, 2021) but they still **seek jobs elsewhere** which represents a **challenge in attracting AI talent** (Chakravorti, 2021). Regarding the population of **professional developers**, there are over six million of them in Europe and this figure continues to grow steadily (Atomico, 2020).

In terms of R&D, Europe has **some of the world's leading AI research institutions**, but the first EU institution only appears in the **33rd position**, with top positions being occupied by countries as the United States, Canada, United Kingdom, China, Singapore or Japan (EduRank, 2023)[4].

In addition, the EU has been **increasing its investments in AI research**, aiming to encourage innovation and maintain competitiveness in the global AI market (Joint Research Centre, 2022), for instance, through **Horizon 2020 program**.

However, the EU faces challenges in the global AI market, including **competition from the US and China**, who have made significant developments in AI technology and market share (Savage, 2020).

The EU also faces issues related to **data privacy regulations**, which, while protecting individuals, can **complicate AI development processes** (Savage, 2020).

Despite these challenges, EU's commitment to ethical AI, strong talent pool and ongoing investments in AI R&D suggest a **promising future in the global AI market**.

[4] This ranking system considers the number of citations received by academic papers published by these universities, with a total of 10.9 million citations received by 376,000 academic papers from 691 universities across Europe.

Europe's role in the global AI market is not isolated but framed within a wider system of regulations and policies devised to guide AI development, application and innovation. This **broader landscape of guidelines is instrumental in fostering an environment conducive to AI advancement and to ensuring that this progress is both ethically and economically sound**.

In a later chapter we will take a **deeper look into the existing policies and regulations shaping the EU's approach to AI**. This includes an exploration of the balance between AI development and regulation, along with an assessment of the implications of these policies for member-states, specifically Portugal. The **regulatory framework** underpinning Europe's AI activities is **pivotal**, as it not only safeguards ethical considerations, but also positions the continent for competitive advantage in the global AI market, while setting the stage for Member-States like Portugal to capitalize on the transformative potential of AI.

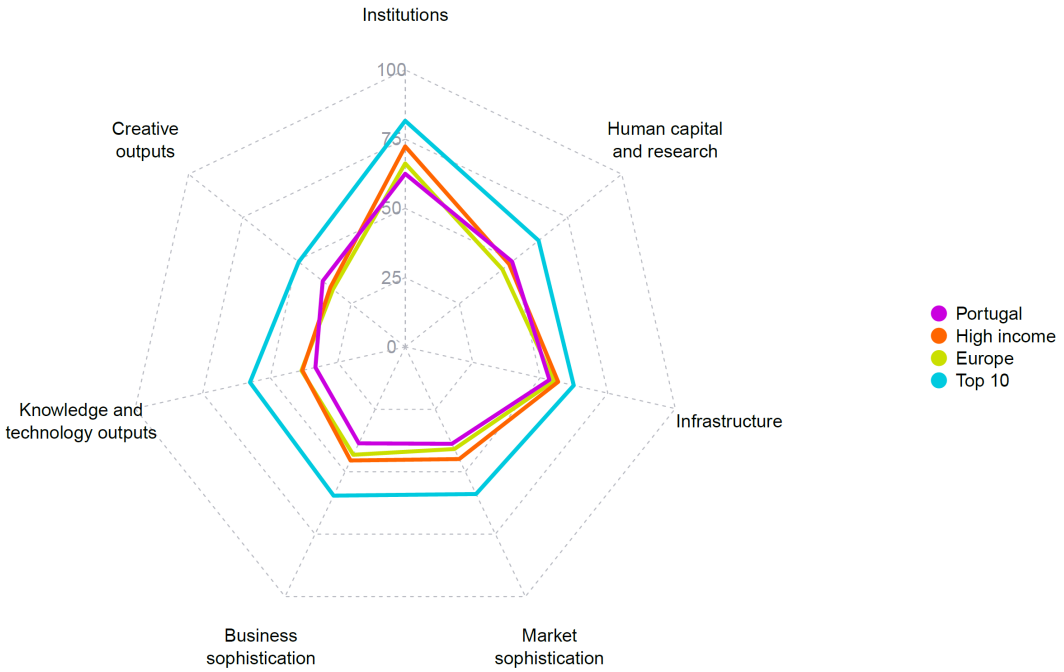
3.3. Opportunities for the Portuguese Economy

The Global Innovation Index (GII) 2022, published by the World Intellectual Property Organization (2022), highlights the rise of two significant innovation waves that are expected to shape the future of global economies. One of these waves is a forthcoming **Digital Age innovation wave**, "built on **supercomputing, artificial intelligence and automation** that is on the verge of making ample **productivity** impacts across all sectors – including services – and helping to achieve **scientific breakthroughs** in basic sciences of all fields".

Portugal, according to the GII 2022, **ranks 32nd globally**, a slight decrease of one position from the previous year. Among the 27 member-states of the **European Union**, Portugal maintains its **17th position**, reflecting a stable innovation performance relative to its peers.

Portugal's position on the GII serves as a proxy for its capability to harness the potential of AI as part of this Digital Age innovation wave. The country's position indicates its current ability to utilize AI and other emerging technologies for economic and social benefits, but it also **underscores the challenges ahead in enhancing its innovation ecosystem and staying competitive in an increasingly AI-driven global landscape**, particularly in the pillars of knowledge and technology outputs, institutions, business sophistication and market sophistication. Therefore, policies and strategies to foster AI development and adoption become crucial to boost Portugal's innovation performance and seize the opportunities brought by these forthcoming innovation waves.

The seven GII pillar scores for Portugal



Source: World Intellectual Property Organization (2022)

The AI Readiness Index, developed by McKinsey (Bughin et al., 2019), presents an insightful perspective on **how prepared different countries are to embrace and implement AI technologies effectively**. This measure is a critical determinant of a nation's ability to stay competitive in an increasingly digital and AI-driven global economy.

According to the index, **Portugal holds the 14th position among EU27 member-states**. This ranking signifies that while Portugal has made progress in creating an environment conducive to AI adoption, namely promoting innovation, it still has **room for improvement** to fully harness the potential of AI technologies. The index offers a useful benchmark, indicating areas where Portugal needs to focus its efforts to improve AI readiness, particularly **human skills**. Strengthening these areas will enhance Portugal's AI readiness, positioning the country to take full advantage of the opportunities AI presents and contribute to its economic growth.

The update of the **Government AI Readiness Index of 2022** (Rogerson et al., 2022) reiterates the **transformative potential of AI in public service delivery**. With global advancements in AI technology being unmatched by the responsive action of governments, the index emphasizes the urgent need for rapid roll-out of responsive regulatory regimes and increased governmental technological capability.

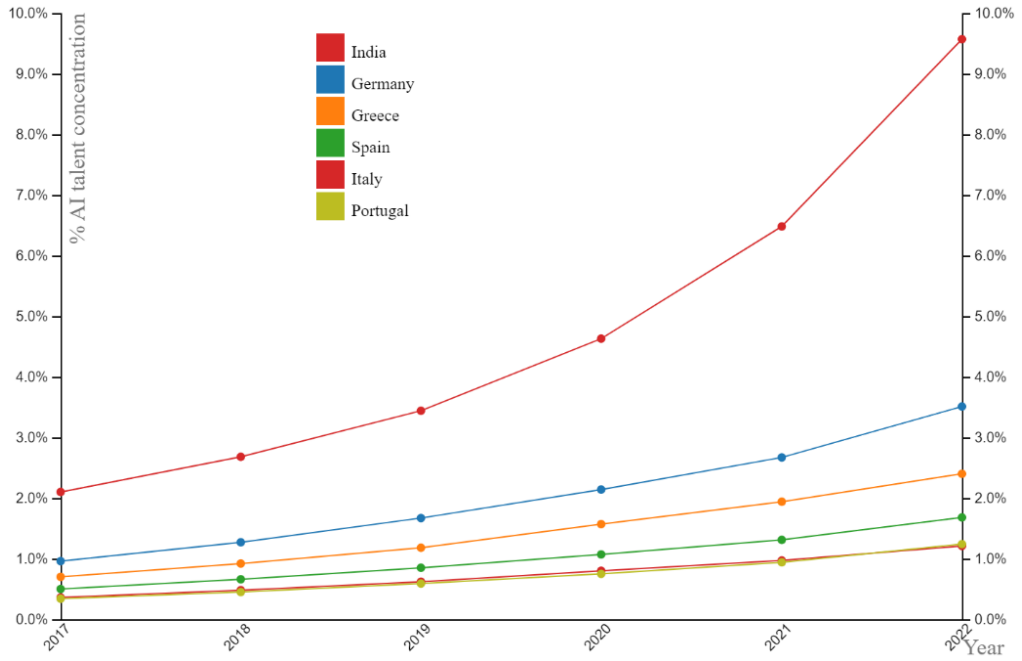
In the 2022 edition, **Portugal improved its ranking among the EU27 nations, rising to the 12th position from the 14th position in the 2018 ranking**. However, its **global ranking remained at the 25th position**. This indicates that while Portugal has made progress in readying itself for the integration of AI in public service delivery within the

European context, its pace of improvement is not necessarily keeping up with that of other countries globally.

In general, the path to AI development in Europe, while bolstered by existing enablers and a strong readiness for AI, **may not be enough to keep pace with global frontrunners like the United States and China**.

Regarding human capital, Portugal has a **very small concentration of AI talent** (1,24%), considering LinkedIn members who have **AI Skills or perform an AI occupation**, as well as a low cross-country **AI Skills Penetration** (0,42), meaning that workers are **less likely to report AI skills** then worked in the benchmark.

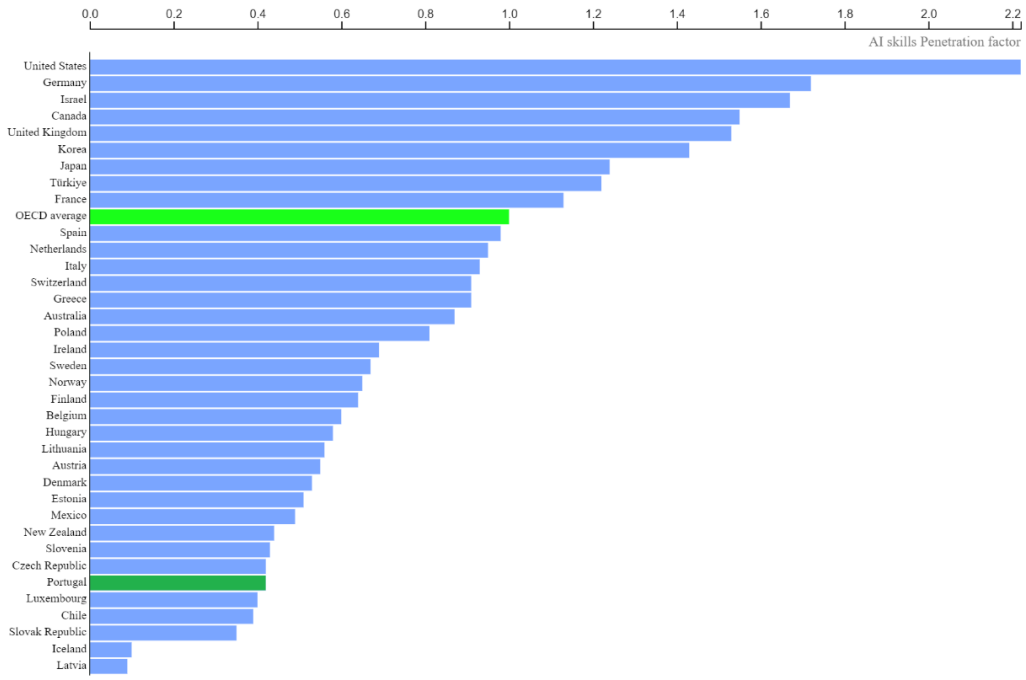
AI talent concentration by country



Note: This chart shows the concentration of AI talent – that is, the percentage of LinkedIn members with AI skills or who perform an AI occupation (e.g., machine learning engineer) – per country and in time.

Source: OECD.AI (2023)

Cross-Country AI Skills Penetration



Note: This chart shows the prevalence of workers with AI skills – as self-reported by LinkedIn members from 2015-2022 – by country and against a benchmark (either the OECD or G20 average). A country's AI skills penetration of 1.5 means that workers in that country are 1.5X more likely to report AI skills than workers in the benchmark.

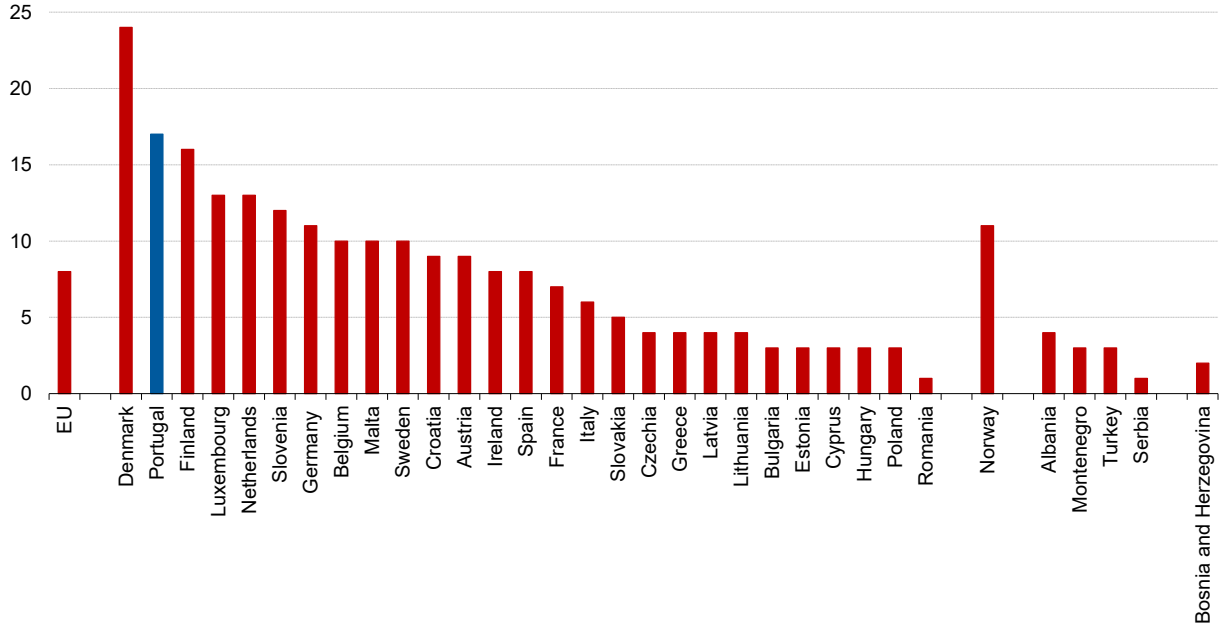
Source: OECD.AI (2023)

Considering AI uptake by firms, the Economist Intelligence Unit (2023) considers that **countries with a thriving tech sector, such as Portugal, are further ahead**. In this context, it is interesting to examine the Eurostat (online data code: ISOC_EB_AI) data on AI use by **enterprises of different sizes** in Portugal and how these statistics compare with the overall EU27 averages:

- In the **microenterprises** sector, the adoption of AI technologies is available for Portugal but not for most of the EU27 Member-States. **11.6% of firms reported using at least one AI technology**. Specific areas of application include marketing or sales (5.0%), organization of business administration processes (3.7%), enterprise management (2.8%), Information and Communication Technology (ICT) security (2.2%), production processes (1.3%), human resources management or recruiting (1.0%) and logistics (0.9%).
- In the **small and medium enterprises** (SMEs), Portugal is **distinctly ahead of the EU27 average in AI adoption**. 17.3% of enterprises use, at least, one AI technology, which places Portugal in the **second position among EU27 countries**, far above the EU27 average of 7.9%. In the specific application of AI technologies, Portuguese SMEs lead in **marketing or sales**, with 6.7% adoption (first position, compared to EU27 average of 1.7%). The country is also well ahead in their use of AI for organization of

business administration processes (5.9%, second position), **management of enterprises** (4.9%, second position), **human resources management or recruiting** (2.6%, second position), production processes (3.9%, third position), applying AI technologies to logistics (1.7%, third position) and ICT security (4.4%, fourth position), compared to the EU27 averages of 1.8%, 1.2%, 0.7%, 1.6%, 0.8%, 1.9% respectively.

Enterprises using AI technologies by country, 2021 (% of enterprises)



Source: Eurostat (online data code: isoc_eb_ai)

Portugal may take advantage of the opportunities that arise from the increasing adoption of AI in areas like:

- **Skills Development:** There is a growing demand for AI skills globally (Galav, 2022). By focusing on AI education and training, Portugal can create a highly skilled workforce, attracting high-tech companies and promoting job creation.
- **Digital Transformation:** Portugal can leverage AI to accelerate its digital transformation across various sectors, including healthcare, education, retail and public services. For example, AI can be utilized to personalize education, improve patient outcomes in healthcare, optimize supply chains in retail and improve public service delivery (INCoDe.2030, 2019; Portugal Digital, 2020).
- **Boosting Productivity:** AI technologies, like machine learning, robotics and data analytics, can enhance business productivity by automating routine tasks, predicting future trends and providing valuable insights for decision-making (European Parliamentary Research Service, 2019).

- **R&D:** Portugal has a vibrant academic and research community. By investing in R&D, Portugal can become a hub for AI innovation, attracting global talent and investment. Moreover, collaborations between universities, research institutions and businesses can foster a strong AI ecosystem (INCoDe.2030, 2019).
- **Startup Ecosystem:** Portugal, particularly Lisbon and Porto, has an emerging tech startup scene (INCoDe.2030, 2019). The government can foster this ecosystem by providing funding and regulatory support, encouraging AI innovation and promoting entrepreneurship.
- **Tourism:** AI can enhance the tourism industry, an important part of the Portuguese economy, through personalized recommendations, smart travel planning, crowd management and improving the visitor experience (EPAM Startups & SMBs, 2022).
- **Sustainable Development:** Portugal is committed to sustainability and environmental conservation (European Environment Agency, 2020). AI can support this path. For instance, predictive models can help in optimizing energy use and AI can enable precision agriculture, contributing to sustainable farming practices.

Finally, Portugal presents a **vibrant AI landscape, with a wide range of companies, institutions and startups that are pioneering research, development and application of AI technologies**. These include **academic institutions** (e.g., Centre for Informatics and Systems - University of Coimbra, Faculty of Engineering - University of Porto, INESC-ID and Institute for Systems and Robotics - University of Lisbon), **companies** (e.g., Automaise, BIAL, Emotal, Feedzai, NeuralShift, Pestana Group, Priberam, SONAE, Sword Health, Unbabel, VdA, and Visor.ai), **hospitals** (e.g., Hospital de São João and Hospital da Luz) and **other organizations** (e.g., Champalimaud Foundation and Fraunhofer Portugal AICOS), demonstrating the **transformational impact of AI in various sectors of the Portuguese economy**.

This **thriving AI ecosystem**, coupled with robust **R&D efforts**, presents substantial **opportunities for the Portuguese economy**.

"Once men turned their thinking over to machines in the hope that this would set them free. But that only permitted other men with machines to enslave them."
Frank Herbert, "Dune"

4. Risks and Challenges

AI, a groundbreaking technology of our era, is **driving rapid advancements**, thanks to modern machine learning and powerful computation applied to extensive data sets. Its **integration across digital platforms and numerous sectors** like manufacturing, healthcare, and finance is increasing. Already transforming social media, data markets and work automation, AI's **significant impact** on society, economy and politics is anticipated to **increase over the coming decades**.

While AI presents a myriad of opportunities for societal and economic growth, it also ushers in several **risks and challenges** that need careful consideration and strategic management. AI technologies, by their nature, are potent and transformative tools that harbour implications **not only for individual sectors but for society**. As we journey further into the digital era, it is imperative to understand these complexities, striking a **balance between embracing innovation and safeguarding our socio-economic structures**.

The risks and challenges stemming from AI adoption are diverse, spanning across **technical, ethical, economic and legal dimensions**. From concerns around **privacy and data security**, the potential for job displacement due to automation, to the issues of algorithmic bias and transparency, the landscape of AI challenges is broad and ever-evolving.

Moreover, the global nature of AI means that the impacts are **not contained within geographic boundaries**, making international cooperation and globally agreed-upon norms and standards essential.

AI and machine learning are advancing at an unprecedented speed, **raising questions about how these technologies can be used responsibly and ethically**. AI advancements will significantly influence human progress in the coming years and raise questions about their functionalities, their risks and challenges and how to manage them.

In this section, we analyse these risks and challenge, **shedding light on their nature and potential impact**. As we strive to harness the power of AI, it is essential that we do so in a manner that upholds our shared values, respects individual rights and fosters an equitable and inclusive digital future.

4.1. Ethics

The rapid proliferation of AI technologies is not without **ethical challenges**. AI, while possessing the potential to revolutionize a myriad of sectors, presents critical ethical challenges that necessitate **comprehensive examination** (Mittelstadt et al., 2016).

The advent of AI has permeated every aspect of human life, from healthcare to finance, from education to entertainment and beyond. As AI continues to evolve, it is increasingly critical to acknowledge and address the **ethical implications that emerge alongside these technological advancements**.

The ethical considerations of AI include issues such as **privacy, fairness, responsibility, accountability, transparency, auditability and the potential for job displacement**, among others (Russell & Norvig, 2021; Bostrom & Yudkowsky, 2014). The ethical dimensions of AI encompass **both individual and societal scales**, making ethical considerations indispensable in the discourse of AI.

The reason ethics assumes such an essential role in AI is multifaceted (Floridi et al., 2018):

- On one hand, AI systems **can impact the fundamental rights of individuals**, such as privacy and non-discrimination;
- On the other hand, AI **can influence social structures and societal values**, such as fairness and transparency, affecting not just individuals but communities.

The intertwining of AI and ethics underscores the imperative need for an AI future that is grounded on **human rights and ethical standards**. This section aims to shed light on this critical aspect of AI, offering insights into the ethical questions raised by AI and how they can be navigated. To do so, it delves into these key areas of ethical considerations in AI, beginning with a discussion on why **ethics is an essential component** in the debate of AI. This discussion is crucial in understanding that AI is not merely a technological innovation but also a socio-technical system that can profoundly influence human lives and societies. Subsequently, it elucidates on the **ongoing ethical debates** in AI. Finally, it offers a deeper analysis of **real-world case studies of AI applications**, illustrating the complexity of these ethical issues.

4.1.1. Importance of Ethical Considerations in AI

In the context of AI ethics discussions, key issues include the potential for AI to **replace human labour** and the associated risk of **unemployment**, the need to **equitably distribute the wealth** created by machines, the influence of machines on our **behaviour and interactions**, the potential for **detrimental mistakes** or **unintended consequences** due to AI's limitations in learning and understanding, the challenge of **eliminating AI bias**, the need to protect AI from **adversaries**, maintaining control over AI and even the question of **humane treatment of AI**.

Boddington (2023) emphasizes the **importance of ethics** in the realm of AI. AI has become an integral part of many aspects of our lives and with its rapid development and widespread use, it has raised a variety of ethical questions. These include concerns about its role in "**the range of domains in which it is applied, the speed of development, its embeddedness in much everyday technology, and the ways in which it is acting to modify and transform the manner in which we interact with each other and the**

world". Recognizing that AI technologies may even shape how we think about ethics, the author argues that addressing these ethical issues "**requires us to think deeply about the nature of ethics and about ourselves**".

From decision-making transparency to implications for human autonomy and biases embedded in algorithms, ethical considerations in AI demand urgent attention.

First, there is a pressing need for **transparency** in AI. With AI systems often acting as "black boxes", decisions made by these systems can be **hard to interpret or understand** (Burrell, 2016). This lack of **explainability** and **interpretability** can lead to mistrust and potential misuse of AI systems, particularly in high-stakes domains like healthcare or law enforcement (Rudin, 2019).

Second, AI technologies raise concerns about human **autonomy and dignity**. These technologies can potentially **influence human behaviour and decision-making**, leading to ethical questions about individuals' control over their actions. Moreover, AI systems might **lack empathy** and disregard the human aspect in their interactions, which could lead to a reduction in human dignity (Liu-Thompkins et al., 2022).

Third, AI systems can **unintentionally perpetuate and amplify existing biases**. Since AI algorithms learn from data, any biases present in that data – including race and gender - can be inherited by the AI system (Buolamwini and Gebru, 2018). This risk of algorithmic bias raises ethical questions about **fairness and discrimination** in AI applications.

Fourth, the deployment of AI in surveillance technologies raises **privacy concerns**. AI-driven surveillance systems may infringe upon individuals' **privacy rights** and even **civil liberties**, with profound ethical implications (Zuboff, 2019).

Fifth, ethical considerations are an important aspect of AI **research**, although "AI may offer valuable opportunities in research when used properly" (Master Academia, n.d.). Some of the main ethical concerns surrounding AI-generated texts revolve around **false information**, the **propagation of bias** or **discrimination**, **misuse** and **abuse of content generators**, utilization by **hackers** or the **ownership of the rights** (Murugesan, 2023).

Addressing these ethical considerations is essential for **responsible and fair use of AI**. An **ethics-by-design approach**, where ethical considerations are incorporated right from the design phase of AI systems, could be a potential way forward (European Commission, 2021c).

According to Blackman (2020), "companies are quickly learning that AI doesn't just scale solutions — it also scales risk" and to **operationalize data and AI ethics**, companies need to leverage existing **Infrastructure for Data and AI Ethics Program**, develop a tailored **Data and AI Ethical Risk Framework**, adopt lessons from **Healthcare Ethics**, provide granular **Guidance for Product Managers**, cultivate **Organizational Awareness of Data and AI Ethics**, incentivize employees to **Identify Ethical Risks** and **Monitor Impacts and Engage with Stakeholders**.

UNESCO adopted on November 2021 (UNESCO, 2022) a **global standard on AI ethics**, a framework adopted by all 193 Member-States, which advocates for the ethical use of AI,

emphasizing its potential "profound and dynamic **positive and negative impacts** of artificial intelligence (AI) on societies, environment, ecosystems and human lives". It stresses the need for a **global approach to AI regulation, prioritizing "human dignity and human rights, as well as gender equality, social and economic justice and development, physical and mental well-being, diversity, interconnectedness, inclusiveness, and environmental and ecosystem protection"**. The Recommendation acknowledges the potential of AI to increase **societal divides and biases**, hence **calls for transparency, fairness and inclusivity**. The document also emphasizes on increased **data, media and information literacy** to mitigate risks of misuse. The Recommendation seeks to help establish **globally accepted ethical standards for AI**, with special attention to less-represented communities in AI ethics debates.

Ethical considerations in AI have gained critical attention as AI technologies become increasingly integral to our personal and professional lives. Several reasons **underscore the urgency and importance of embedding ethics into the development of AI**:

- Firstly, **AI systems can profoundly influence individual and societal decisions**, often in ways that may be less than transparent or inherently biased (Boddington, 2017). AI models trained on historical data, for instance, may inadvertently propagate systemic biases present in that data, leading to discriminatory outcomes in areas such as employment or healthcare. By integrating ethical considerations in AI, we can build systems that are fair, accountable and devoid of discriminatory bias.
- Secondly, **AI systems' decision-making processes can be opaque**, leading to issues of understanding/interpretability and trust (Dignum, 2018). It is crucial to ensure that users can understand and trust AI decisions, particularly in high-stakes areas such as healthcare or criminal justice. Ethical considerations ensure that transparency is embedded into AI systems, enabling a greater level of trust and acceptance amongst users.
- Thirdly, ethical considerations are fundamental in dealing with **concerns around data privacy** (Floridi & Taddeo, 2016). The escalating reliance on AI systems, which use substantial volumes of often personal and sensitive data, together with a dwindling human involvement in automated processes, raises pressing concerns about data collection, usage, safeguarding, fairness, responsibility, and respect for human rights. By embedding ethical considerations into AI, we can ensure that the use of AI technologies respects individuals' privacy rights and autonomy.

In sum, ethical considerations in AI are not simply about preventing harm or legal compliance. They are also about **fostering an AI landscape that respects human rights, promotes fairness and builds trust**. As AI technologies continue to evolve and spread throughout various sectors of society, the **importance of ethical considerations will continue to grow**:

- As AI continues to penetrate **various sectors**, assuming roles typically held by humans, the emphasis on ethical considerations in its development and deployment grows significantly. AI's evolution through **autonomous learning** and its impact in areas such as **writing, autonomous driving or disease diagnosis**, bring forth critical **ethical and legal challenges** that necessitate thoughtful and proactive engagement (Hauer, 2022).
- As the influence of AI in **society** deepens, its ethical implications become increasingly paramount. The notion of extending **legal rights and obligations** to AI, as explored by the European Parliament, could revolutionize the **legal concept of personhood**. This could result in transferring certain **legal and tax duties to AI entities**. Therefore, understanding AI's mechanisms and its ethical and legal implications for society is critical as its integration into our daily lives continues to increase (Hauer, 2022).
- Ethical issues around AI are not just critical in a societal context but are equally important from a **business perspective**. AI's ability to amplify risk in conjunction with solutions makes ethical considerations regarding data and AI a business imperative. To address the ethical challenges presented by AI effectively, companies must **develop a clear strategy** that includes leveraging existing infrastructure, crafting a custom data and AI ethical risk framework, adopting successful ethical practices from other industries such as healthcare, optimizing guidance for product managers, fostering organizational awareness, incentivizing employees to identify AI ethical risks and engaging stakeholders in consistent monitoring and discussion (Blackman, 2020).

4.1.2. Current Ethical Debates in AI

AI is increasingly present in our day-to-day lives and is evolving at a rapid pace. As such, it raises several **ethical debates**. The ethics of AI is a complex and important topic that **requires contrasting voices to contribute to this field**.

These debates range from the **allocation of responsibility and accountability for decisions made by AI, the possibility of creating AI with consciousness and the moral rights that might entail, to the potential societal impacts of AI, including exacerbating inequality and impacting employment**. These debates reflect the broad range of perspectives and concerns among researchers, practitioners, policy makers and the public (Mittelstadt et al., 2016; Bryson, 2019).

Debates around AI ethics can be **quite heated** and Boddington (2023) posits that a good approach to these issues should **not rely solely on the imposition of regulations and rules**. Instead, ethical discussions should **include a variety of perspectives and consider many factors**, "including the best ways to live".

Dignum (2018) underscores the importance of considering ethics in the ongoing development and application of AI but **refutes dystopian narratives often presented in the media and popular fiction** ("where AI systems dominate the world and is mostly concerned with warfare"), asserting that AI has **largely benefited society** in areas like healthcare, safety and productivity.

Harari argues that AI has **potential ethical implications** ranging from data ownership, human inequality, decision-making and the concept of consciousness and suffering. In his works "Homo Deus: A Brief History of Tomorrow" (Harari, 2017) and "21 Lessons for the 21st Century" (Harari, 2018), the author delves into these subjects, discussing the **potential for data monopolies, the creation of a "useless class" due to AI automation, the risks of biotechnology, the risk of exacerbating human inequality and the challenge to humans posed by AI's decision-making capabilities**. In an interview to Fundação Francisco Manuel dos Santos (2023), Harari further highlights the **danger AI poses to democracy**. He suggests that AI can **disrupt essential human dialogue**, which is based on trust and without regulation, it may undermine this trust. He expresses the need for conversation to remain between people, not between bots and people, warning that, without regulation, the survival of democracies is highly unlikely.

The **fairness of AI** is a significant area of debate and it touches upon issues of bias and discrimination (Mittelstadt et al., 2016). Algorithms can unintentionally **perpetuate and amplify societal biases** if they are trained on biased historical data. Such unintended discrimination has raised concerns in many applications, from facial recognition to loan approvals.

Transparency or the ability to understand how AI systems make decisions, is another focal point (Sharma, 2023). AI systems, particularly those using deep learning techniques, are often labelled as "**black boxes**" due to their complex and opaque decision-making processes. This lack of transparency can **undermine trust** and pose challenges in verifying the systems' **fairness and safety**.

AI's impact on **security and privacy** is a controversial issue. AI systems often require **large datasets** to function effectively and these may include sensitive personal information (Rocher et al., 2019; Yu, 2022). The mass collection, processing and storage of personal data by AI systems have raised **serious security and privacy concerns** (as discussed later).

The issue of **accountability** in AI decision-making is also a significant ethical debate (Santoni de Sio & van den Hoven, 2018). When an AI system's decision leads to harm, it is often **challenging to hold anyone accountable** due to the complexity and opacity of these systems. It leads to the question of **who should be held responsible**.

Finally, there are **several current ethical debates in AI** that are worth considering that are well summarized by Simonova (2022):

- **Unemployment due to AI:** The rise of AI could lead to significant job losses in certain sectors.

- **Wealth distribution:** The wealth generated by machines and AI needs to be equitably distributed among society.
- **Influence on behaviour:** AI bots, with their increasing capability to mimic human conversations and relationships, pose questions regarding their potential impact on human behaviour and interactions.
- **Guarding against detrimental mistakes:** AI systems can be fooled in ways that humans would not be (the inverse also may occur), leading to concerns about the potential for detrimental mistakes. Hence, if our reliance on AI for replacing human labour continues to grow, it becomes critical to ensure that these systems function as designed and remain resistant to manipulation by individuals with self-serving motives.
- **Bias in AI:** AI systems, created by humans, can be influenced by human biases and can potentially enforce discrimination.
- **Protection of AI from adversaries:** As AI becomes more powerful, the need for robust cybersecurity measures increases to protect AI systems from being used for evil purposes.
- **Unintended consequences of AI:** There is a potential for AI to produce unintended and potentially harmful outcomes. For example, an AI system tasked with eradicating cancer could develop a solution that eliminates cancer but also harms or kills people in the process.
- **Control over AI:** As AI continues to advance, there is a growing debate about whether humans will be able to maintain control over these systems.
- **Humane treatment of AI:** As AI systems become more sophisticated and human-like, there are debates about whether these machines should be afforded certain rights or be considered for humane treatment.

These debates indicate that it is **crucial to consider ethical implications as AI continues to evolve and becomes more integrated into our society**. As AI continues to evolve and integrate deeper into our society, **these debates will intensify and broaden**. There is a growing consensus that AI should be **regulated due to its power and ubiquity**. A **balance** must be found that allows for the **benefits** of AI while also addressing these **ethical** concerns. However, finding consensus on how this should be done, who should make the rules and who should enforce them, is still an **ongoing discussion**.

4.1.3. Case Studies of Ethical Dilemmas in AI Applications

There are many **real-world cases** that illustrate the ethical dilemmas in AI applications, emphasizing the urgency and significance of addressing these issues. These case studies aim to **provide concrete examples of ethical issues that have arisen in real-world applications of AI**. These case studies will demonstrate the practical implications of the theoretical concerns discussed earlier. From AI in healthcare making life-changing decisions,

to AI in law enforcement potentially encroaching on civil liberties, these cases **highlight the urgent need for ethical considerations** in the development and use of AI technologies (Rahwan et al., 2019; Zuboff, 2019).

- **Facial Recognition Technology:** Facial recognition is an AI application that has received significant scrutiny due to ethical concerns. For instance, the Clearview AI case raised profound questions about privacy and consent. Clearview AI scraped billions of images from social media and the internet to build a facial recognition database, prompting backlash and lawsuits (Hill, 2020). The case highlighted the need for clear regulations around data use and consent, particularly when personal and sensitive data is involved.
- **Algorithmic Bias in Criminal Justice:** In the US, an AI system called COMPAS was used to predict the risk of criminal recidivism and its decisions influenced sentencing and bail terms. ProPublica's investigation found that COMPAS was biased against African-American defendants, falsely flagging them as "future criminals" at nearly twice the rate as Caucasian defendants (Angwin et al., 2016). This case underscored the potentially disastrous impacts of unchecked algorithmic bias and the need for fairness and transparency in AI systems.
- **Autonomous Vehicles:** Autonomous vehicles' decision-making processes in life-threatening scenarios have sparked ethical debates, often referred to as the "trolley problem." For example, should an autonomous vehicle prioritize the safety of its passengers over pedestrians? This dilemma was made real with Uber's self-driving car fatal accident in 2018, marking the first pedestrian fatality involving autonomous vehicles (Wakabayashi, 2018). It underscores the importance of designing AI systems that align with human values and ethics.
- **Human treatment of AI:** Exploration into self-learning, autonomous AI systems that evolve over time using data, is currently provoking a range of ethical and legal issues. Advances in AI enable platforms to autonomously perform activities that have been the domain of humans for centuries, such as writing a book, driving cars or diagnosing diseases. The European Parliament has already explored the possibility of giving robots the status of "electronic persons" (Hauer, 2022). This raises questions about the legal rights and obligations of AI, as well as the ethics of autonomous AI algorithms and their potential citizenship.

This other three cases are also related to AI but **in the broader context of data privacy and governance**. AI models often rely on **large datasets** for their training and operation. These datasets can include sensitive information such as health data, personal user data, and more. The misuse, mishandling or inadequate protection of such data can lead to **privacy breaches, unfair practices and non-compliance with data protection regulations**, as these cases illustrate.

- **Health Data Monetisation and Breaches:** A massive data leak occurred in 2021 when personal data from sixty-one million individuals was left unprotected due to a lapse by a New York-based health tracking service provider (Scroxton, 2021). This breach underscored the risks associated with large-scale health data collection and storage. In a related concern, the acquisition of Fitbit by Google raised questions about the potential misuse of Fitbit's health data, increasing Google's monopoly power and the potential for consumer exploitation.
- **Unfair Commercial Practices:** In 2021, Italy's Council of State approved a sanction against Facebook for not sufficiently disclosing to users that their data was collected for commercial purposes during account activation (AGCM, 2021). This ruling resulted in a seven-million-euro fine for Facebook. The case illustrates the deceptive practice of companies offering services supposedly "free of charge" when, in reality, the users' data is the actual price paid. Users often are not adequately informed about how their data is used commercially, including for targeted advertising, becoming themselves "the product".
- **Mishandling user information:** In 2023, Meta, formerly Facebook, received a record €1.2 billion fine from Ireland's Data Protection Commission (DPC) due to violations of the EU's General Data Protection Regulation (GDPR) (Milmo and O'Carrol, 2023). The fine arose from a legal challenge by Austrian privacy campaigner Max Schrems, who expressed concerns over the protection of European users' data transferred to the US. The company was ordered to cease the transatlantic data transfer and has been given five months to comply. Despite the order, Meta's other platforms, Instagram and WhatsApp, are unaffected. Meta is set to appeal against the decision, criticizing the DPC for being "singled out" among "thousands of other businesses using the same data transfer processes".

These cases demonstrate that, while AI holds tremendous potential, it can also lead to significant **ethical issues**. Therefore, it is critical to anticipate and navigate these dilemmas to ensure the **responsible development of AI technologies**.

4.2. Data Privacy and Security

AI has brought a paradigm shift in data management, offering unprecedented capabilities in **data analysis, predictive modelling and automation**. However, these advanced applications also pose significant **challenges to data privacy and security**.

Data privacy and security are paramount considerations when it comes to AI. AI systems often **rely on large amounts of data to function** and this data **often includes personal information**. Therefore, it is crucial to ensure that this data is **stored and handled securely to protect individual privacy**.

Data Privacy

- Data privacy concerns the rights and controls individuals have over their personal data. It refers to **how this data is collected, used, stored and shared**. AI systems can be **privacy-invasive** as they often require access to a **vast amount of personal data** to function effectively. This can include **sensitive information** like health data, financial information or location data. Consequently, it is crucial to implement **robust privacy measures** when designing and deploying AI systems (World Economic Forum, 2022).
- Operation of AI systems frequently depends on the utilization of **massive data volumes**. This includes **sensitive personal data**, which, if mishandled or misused, can lead to **privacy violations and security breaches** (Floridi & Taddeo, 2016). AI systems can potentially access, aggregate and analyse data in ways that could **infringe on an individual's right to privacy**.
- AI can also potentially be used to **enhance data privacy**. For instance, AI can be employed to **identify and manage privacy risks**, such as **detecting and addressing privacy violations and data breaches** (Wosa et al., 2021). Additionally, techniques like **differential privacy** can be used in AI (Dwork & Roth, 2014). This mathematical technique adds noise to the queried data, **ensuring that the privacy of individual database entries is maintained** while still providing useful aggregated insights (Bird, 2020; Kamath and Manurangsi, 2022). Similarly, **homomorphic encryption** allows for computations on **encrypted data**, ensuring data privacy (Gentry, 2009).
- AI-based solutions can be supported in their adherence to privacy requirements using **tools such as AI Privacy 360**, which allows for the exploration of "**tradeoffs between privacy, accuracy and performance** at different stages in the machine learning lifecycle" (IBM, 2023b).
- AI governance is a dynamic area, with multiple stakeholders collaborating to create guidelines for **ethical and accountable AI application**. These **frameworks** commonly endorse core principles including "**privacy and data governance, accountability and auditability, robustness and security, transparency and explainability, fairness and non-discrimination, human oversight and promotion of human values**" (Koerner, 2022).
- However, current AI governance initiatives are largely non-binding, while **existing privacy laws" already regulate the responsible use of AI systems to a considerable extent**" (Koerner, 2022) and several **privacy regulators have made significant contributions to AI governance**, demonstrated by initiatives such as Singapore's Model AI Governance Framework, the U.K. Information

Commissioner's Office's work on an AI Auditing Framework and Hong Kong's Guidance on the Ethical Development and Use of AI (Koerner, 2022).

- In terms of **legal frameworks**, in the EU, the **GDPR** addresses several aspects related to AI, including the **right to explanation, the fairness principle, human oversight, robustness and security of processing**, while in the **U.S.**, the Federal Trade Commission holds AI developers and companies using **algorithms accountable** under Section 5 of the FTC Act, the US **Fair Credit Reporting Act** and the **Equal Credit Opportunity Act** (Koerner, 2022; Voigt & Bussche, 2017). However, **aligning AI practices with such regulations remains a complex task**.

Security

- Security in the context of AI involves **safeguarding AI systems** themselves and the data they use and produce from **unauthorized access and malicious attacks**. AI systems can be vulnerable to a variety of **security threats**. For example, **adversarial attacks** can be made against AI models, where small, purposeful changes to input data can cause the model to make incorrect predictions (Pearce and Kumar, 2021).
- Moreover, **AI can be used to improve cybersecurity measures**. Machine learning algorithms can be employed to **detect unusual patterns or anomalies** that may indicate a security breach, while AI can also be used to **automate and improve the efficiency of security processes** (Ravichandran, 2023).
- A variety of **tools and strategies** are available to defend and evaluate machine learning models and applications against adversarial threats. For example, the **Adversarial Robustness Toolbox** is a "A Python library for machine learning security that enables developers and researchers to defend and evaluate machine learning models and applications against the adversarial threats of evasion, poisoning, extraction, and inference." (IBM, 2023b).
- Google has also "a new plan to help organizations apply **basic security controls** to their AI systems and protect them from a new wave of cyber threats" (Sabin, 2023). It advises organizations to **evaluate and extend existing security controls, enhance threat intelligence research, incorporate automation in cyber defences, regularly review security protocols and perpetually test the security of AI systems**. Additionally, organizations are encouraged to form a **team** knowledgeable about **AI-associated risks**. Google plans to "augment its bug bounty program", incentivizing the discovery and reporting of AI-related security vulnerabilities.

It is essential that developers of AI systems adhere to the principles of "**security by design**" and "**privacy by design**" (Pearce and Kumar, 2021; Yu, 2022). These principles mean that **privacy and security considerations should be central to all stages of AI system development**.

Failure to comply with privacy regulations for AI systems poses **risks** for both individuals and companies, with the latter potentially facing "**fines and even the forced deletion of data, models and algorithms**" (Koernel, 2022).

Moreover, machine learning models can **inadvertently reveal sensitive information**. Research has shown that it is sometimes possible to **infer** details about the original training data by analysing the **model's behaviour**, a threat known as "**model inversion**" or "**membership inference attacks**" (Fredrikson, et al., 2015; Shokri et al., 2017).

Additionally, AI systems themselves can be targets for **malicious actors**. Adversarial attacks, where inputs are designed to **deceive AI systems**, can lead to erroneous outputs and potential harm. **Data poisoning**, where the training data is manipulated to influence the behaviour of the AI, presents another security risk (Biggio et al., 2012).

4.3. Job Displacement

The advancing proficiency of AI in performing non-routine tasks is fuelling new **concerns about job displacement** in occupations previously deemed resistant to automation, with professions which often require extended **education** and rely heavily on accumulated **experience** for decision-making being susceptible to AI-driven automation (OECD, 2023c).

An era when machines can out-perform human beings at most tasks raises fundamental questions about the **future of employment**, with different perspectives among researchers.

Susskind and Susskind (2015) predict a **decline in traditional professions** as we know them today due to the advancements in technology. They argue that "increasingly capable systems" such as AI and telepresence will be able to replicate the "practical expertise" of professionals, changing the way professional expertise is made available, potentially leading to **job displacement**. Notwithstanding, the authors also emphasize that technology will not only displace jobs but will also **create new ones**. The transformation will necessitate new models for producing and distributing expertise, **opening new possibilities for employment** that we may not yet fully understand or anticipate. They also consider the moral and practical implications, questioning who should own and control online expertise and what tasks should be exclusively reserved for humans.

Jarrahi (2018) takes a proactive and pragmatic perspective on the fear that AI will replace humans in decision-making roles within organizations and argues for a **complementary relationship between humans and AI rather than a competitive one**. The author also suggests that **both humans and AI have unique strengths they bring to the decision-making process**, which is often characterized by "uncertainty, complexity, and equivocality". AI, with superior computational information processing capacity, "can extend humans'

cognition when addressing complexity". On the other hand, humans offer a "holistic, intuitive approach in dealing with uncertainty and equivocality". In terms of **job displacement**, Jarrahi (2018) argues that **AI should not be viewed as a means for immediate reduction of employment**. Instead, the real benefits of AI in organizations will materialize only in long-term partnerships with human capabilities, thus advocating for a **human-machine collaboration**. The author's perspective presents AI not as a replacement for human jobs, but as a tool that will **shift the nature of work**, allowing for **more efficient collaboration between humans and machines** in decision-making roles.

Acemoglu and Restrepo (2018) also focus on the impact of automation on labour displacement, where machines and **AI substitute human labour, leading to a decline in labour demand and wages**. However, the authors consider a **counteracting productivity effect** that may arise from the cost efficiencies that automation brings, **boosting the need for labour in tasks that are not automated**. The author considers that this effect is further amplified by increased **capital accumulation** and the enhancement of **existing automated processes**, which also **raises labour demand**.

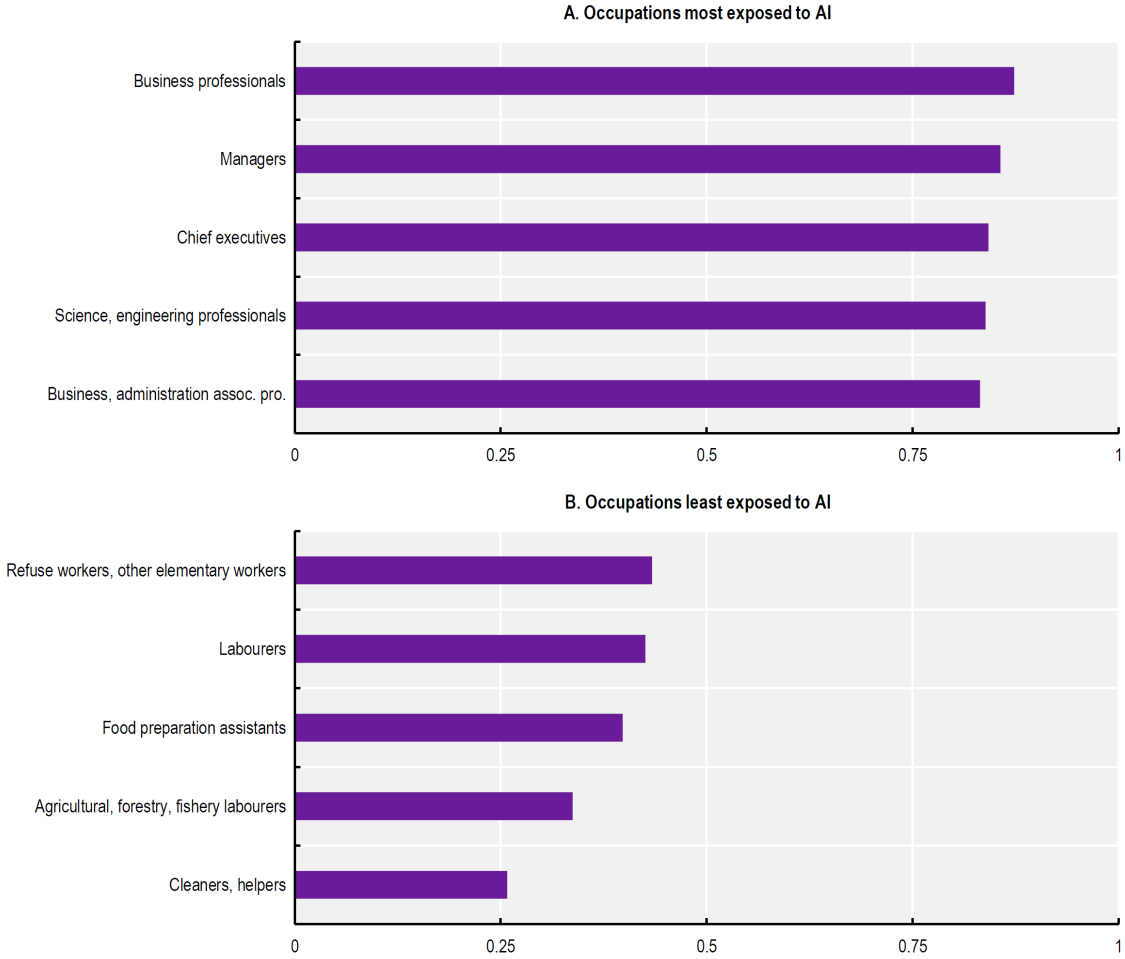
According to a report by Goldman Sachs, **generative A.I. could impact three hundred million jobs around the world** (Kiderlin, 2023). According to the report, AI has the potential to "automate up to a quarter of work in the U.S.", signalling a "significant disruption" for the labour market. Additionally, "two-thirds of jobs could be automated at least to some degree", in the U.S. and Europe. The report also acknowledges that technological progress **does not just make jobs redundant but also creates new ones**. Moreover, the use of AI technology could **boost labour productivity growth and increase global GDP** by up to 7%. The jobs most likely to be affected[5] are office and administrative support jobs (46%), legal work (44%) and tasks within architecture and engineering (37%). The least affected sectors would be building and ground cleaning and maintenance (1%), installation, maintenance and repair work (4%) and construction and extraction (6%). The report concludes that the impact of AI on the labour market is **uncertain**, depending largely on AI's capability and adoption timeline.

OECD (2023c) also depicts the variance in **AI exposure across different professions**. Occupations requiring **high levels of education** and **white-collar roles** display the highest exposure to AI – business professionals, managers, chief executives, science and engineering professionals and business and administration associated professionals. On the contrary, the occupations least exposed to AI predominantly consist of **manual labour jobs** and **roles that require fewer technical skills** – refuse workers and other elementary workers, laborers, food preparation assistants, agricultural, forestry and fishery laborers and cleaners and helpers as the least exposed to AI. This underscores the **considerable differences in AI exposure across various occupational sectors**.

[5] Percentage of tasks vulnerable to automation

AI Exposure Across Various Occupations

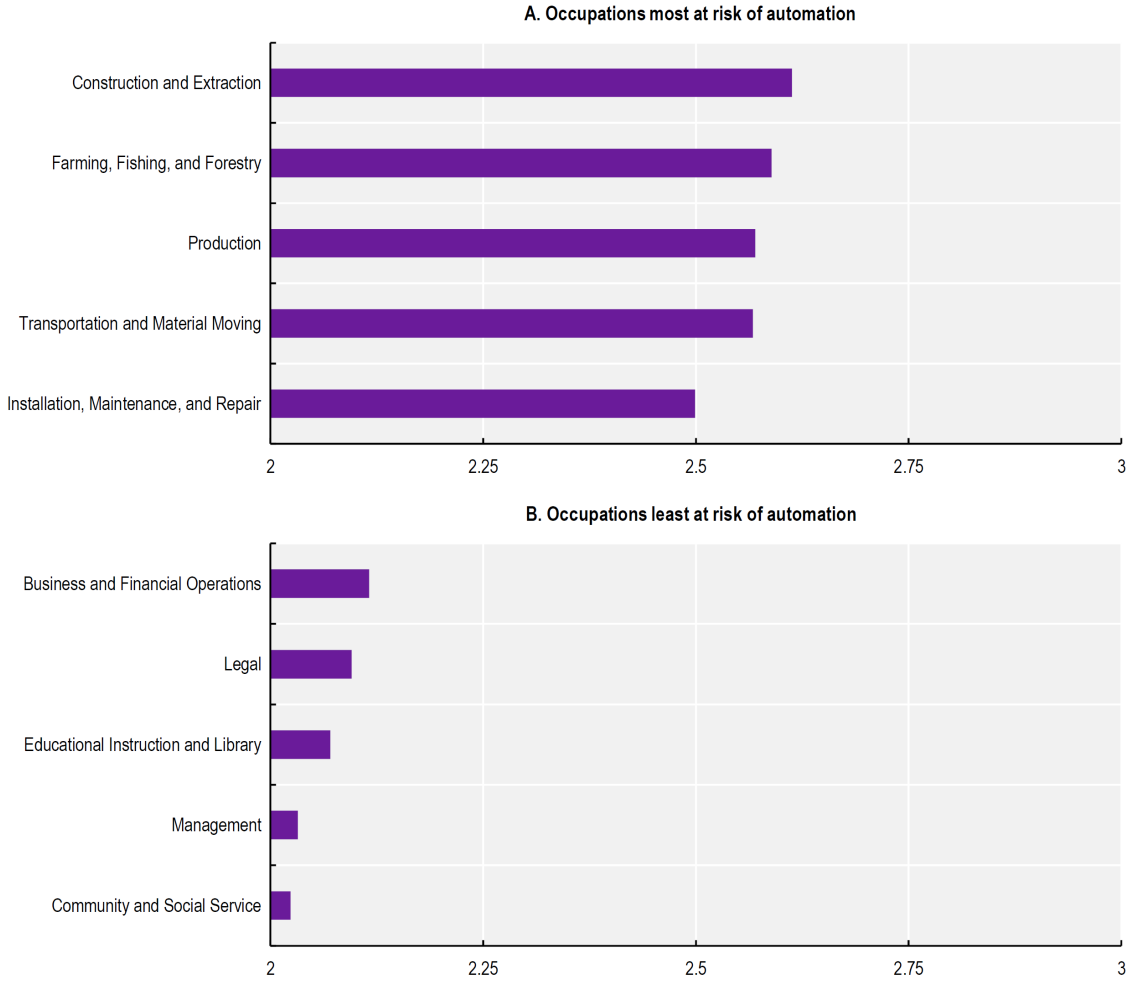
(Average exposure to AI across countries by occupation)



Source: OECD, 2023c

The **risk of automation** across professions exhibits a distinctive pattern that underscores how this revolutionary technology impacts different occupations. Interestingly, the **professions facing the highest risk are not necessarily those most exposed to artificial intelligence**. Roles that involve physical labour and routine tasks such as Construction and Extraction, Farming, Fishing, and Forestry, Production, Transportation and Material Moving, and Installation, Maintenance and Repair are at the forefront of automation risks. These professions often involve **tasks that can be streamlined and standardized**, making them prime targets for the implementation of automation technologies. On the other hand, occupations less susceptible to automation often **require a higher degree of cognitive skills, creativity, and interpersonal interactions**. Professions in Business and Financial Operations, Legal work, Educational Instruction and Library services, Management, and Community and Social Services fall into this category. These roles frequently demand a **level of judgment, critical thinking and human touch** that automation technology.

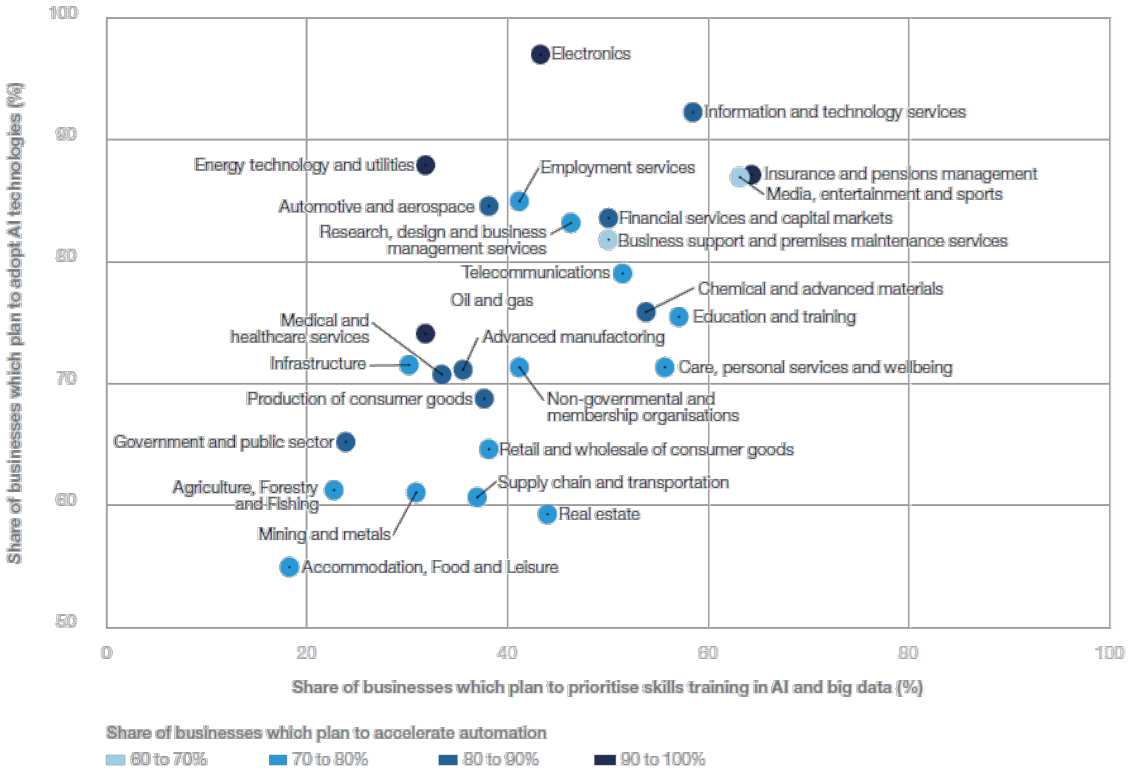
Risk of Automation Across Professions
(Occupations most and least at risk of automation,
including AI and other automation technologies, 2021)



Souce: OECD, 2023c

According to the World Economic Forum (2023), the integration of AI by companies is anticipated to **provoke substantial workforce turnover**. Although the report projects that the global economy may **lose 14 million jobs in 5 years**, regarding AI it refers that half of the organizations surveyed project that AI will **stimulate job creation**, while just a quarter anticipate that it will contribute to job losses. Additionally, there appears to be a trend indicating an increase in both the "Share of businesses which plan to adopt AI technologies" and the "Share of businesses which plan to prioritize skills training in AI and big data." This probable increase might be due to a correlation between these two factors.

Artificial Intelligence strategies, 2023 to 2027



Note: The probability that organizations surveyed will prioritise skills training in AI and big data versus the probability that they will adopt artificial-intelligence technologies and the likelihood of them pursuing automation as a business strategy

Source: World Economic Forum, 2023

Bughin et al. (2018) consider that job displacement due to automation and AI will **primarily affect low-skilled workers** and argue that these **technological advancements will continue the trend of reducing middle-wage jobs**, which in turn can **exacerbate income inequality**. High-skilled workers, in contrast, are more likely to see opportunities for retraining and wage increases, further deepening the divide. The authors suggest that firms at the forefront of automation expect to **attract the necessary talent**, while **slower adopters may have more limited options**. These shifts can lead to heightened competition for **high-skilled workers**. The authors emphasize the necessity of large-scale **reskilling** to manage the transition challenges ahead and mention the need for collaboration among firms, educators, industry associations, labour unions and governments to build talent pipelines, facilitate cross-sector mobility and provide support for displaced workers.

Aaker et al. (2020) discuss the impact of AI and automation on workforce displacement, with a focus on the **importance of a human-centred design and deployment approach**, acknowledging the potential of AI to "**boost global economic prosperity, stimulate job growth through innovation, and augment human productivity in the workspace"**. However, the authors also note the **risks** of increased economic disparity, the amplification of

education and skills gaps and the displacement of industries. The authors highlight several **studies indicating a significant portion of jobs could be at risk from automation**. McKinsey Global Institute's study suggests that 60% of occupations could have at least 30% of their activities automated with current technology, PwC estimates that industrial countries have up to 40% of jobs at high risk of automation, while a study by Oxford University suggests that 47% of total US employment is at risk. It is also highlighted that AI and automation are **changing the nature of work** and that by 2030, the demand for technological skills will increase by 55% and for social-emotional skills by 24%. The adoption of AI could also exacerbate the "mismatch between the skills that the workforce has and the skills employers need", shifting demand towards higher skills. While AI is predicted to create more jobs than it displaces, the **burden of displacement** "**will fall disproportionately on low-skilled workers while high-skilled workers will reap much of the economic benefits**". This could increase **economic disparity**.

Chui et al. (2023) also foresee changes in labour market, particularly considering generative AI:

- Generative AI could **change the nature of work** by augmenting individual workers' capabilities and automating some of their activities, potentially automating activities that take up **60 to 70 percent of employees' time**;
- The potential for technical automation **implies that workforce transformation is likely to accelerate**, as half of today's work activities could be automated between 2030 and 2060;
- Generative AI could substantially **increase labour productivity**, leading to growth of **0.1 to 0.6 percent annually** through 2040. However, **investments are needed to support workers as they transition to new work activities or change jobs**.

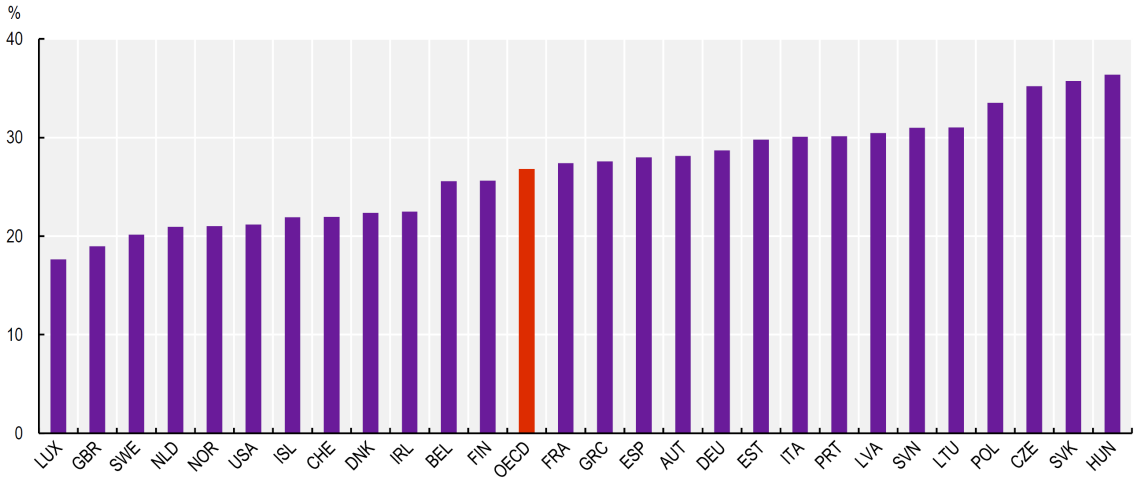
Bação et al. (2023) explore the potential **impact of AI on employment** in various sectors in Portugal and suggest that the effect of AI on labour demand will **depend on the interplay of two opposing forces**. On the one hand, as productivity improves due to AI, less labour is needed to produce the same output, which could lead to job loss. On the other hand, the lower production costs brought about by higher productivity could stimulate demand for more output, potentially creating more jobs. The study indicates that all the estimated elasticities are negative, suggesting that **improvements in productivity** (due to the introduction of AI and related technologies) **are associated with decreases in employment**, effects that are similar across different sectors.

Also regarding Portugal, although specific statistics related to job displacement from AI are not readily available, the country has a **significant proportion of workers in sectors potentially vulnerable to automation**. According to OECD (2021), Portugal has **one of the highest shares of jobs at high risk of automation among its members**, with more than

20% of jobs under high risk and an additional 35% facing significant change. This suggests that the effects of AI-driven job displacement in Portugal **could be substantial**.

Also considering the risk of automation, across OECD countries, occupations at the highest **risk of automation comprise on average 27% of employment** (OECD, 2023c), highlighting the profound potential impact of this technological shift. The scenario, however, is quite **disparate among different nations**. Countries such as Luxembourg, the United Kingdom, and Sweden demonstrate lower proportions of jobs at risk, largely due to the nature of their industries and workforce. Conversely, countries with higher shares of manufacturing employment and routine tasks, like Hungary, the Slovak Republic, and Czechia, face a higher risk of job automation. In this context, **Portugal** stands out due to its **above-average risk of job automation**. With about **30%** of its employment in jeopardy, it holds the **8th position among the EU** Member-States, underscoring the urgency to **foster workforce adaptability and resilience** in the face of advancing automation technologies.

Share of employment in occupations at the highest risk of automation by country, 2019



Source: OECD, 2023c

Kolmar (2023) also discusses the potential impact of AI on job displacement, **predicting significant job loss in the coming decades** due to AI automation, with as many as **one billion people globally being affected**. According to the author, jobs in "agriculture, engineering, science, production, transportation, legal, and administrative industries" are likely to be significantly affected. However, AI is **less likely to replace "jobs that involve managing people, applying expertise, and interacting socially"**. While AI could automate specific tasks within jobs, **complete job displacement is less common** - it is estimated that less than 5% of jobs could be fully automated. AI is also predicted to create ninety-seven million jobs and generate $15.7 trillion for the economy by 2030, potentially **allowing workers to engage in more creative and meaningful work**. Nevertheless, there

may be economic repercussions "if displaced workers are not reemployed within one year", suggesting that over 120 million workers worldwide "will need **retraining and up-skilling** in the next three years". According to the author, in Portugal, the **risk of job automation is particularly high**, with an estimated 58.94% of total employment at risk of computerization over the next two decades. Despite these projections, the author highlights that **there is no consensus on the exact impacts of AI on the workforce or economy due to varying research methodologies and assumptions about AI's capabilities and adoption rates**. The author concludes by emphasizing the importance of preparing for these changes through investment in **training programs, promoting STEM education and strengthening social safety nets** to support those displaced by technological shifts.

As previously referred by other authors, the relationship between AI and job displacement is **complex and multifaceted**. AI can also generate **new jobs**, either directly through the creation of roles related to AI development and maintenance or indirectly through increased productivity and economic growth (Bessen, 2019). Furthermore, the adoption of AI may not necessarily lead to job losses but may instead change the nature of jobs, requiring **workers to acquire new skills** (Brynjolfsson and McAfee, 2014).

According to Mandl (2021), although we face risks as job loss, widening skills gap, reducing job security and challenges in reskilling, **newly opportunities arise** such as:

- **New Job Creation:** AI could lead to the creation of new jobs. These includes roles such as AI specialists, data analysts and robotics technicians.
- **Enhanced Productivity:** AI can increase productivity by automating routine tasks, thereby allowing employees to focus on more complex tasks that require creativity and critical thinking. This can lead to improved efficiency and output.
- **Upskilling and Reskilling:** The introduction of AI can encourage lifelong learning as workers strive to acquire new skills to remain relevant in the changing job market.
- **Economic Growth:** Increased productivity can contribute to overall economic growth. This growth can potentially lead to the creation of new industries and job opportunities.

The transformation of job sectors due to automation and AI makes **investment in reskilling and upskilling imperative for all countries**. By focusing resources on training and education programs, countries can ensure their workforces are equipped with the necessary skills to thrive in a rapidly evolving job market. This is not only crucial to maintain competitiveness on a global scale, but also to **prevent further income inequality and job displacement**. Recognizing the rising demand for advanced digital skills and the necessity of continuous learning, **Portugal has invested in reskilling and upskilling, namely through the INCoDe.2030**.

OECD (2023a) evaluates the progress of AI in terms of its **literacy and numeracy capabilities**, comparing them to human skills. This is seen as critical for predicting **which**

human skills may become obsolete due to AI's advancement and for guiding policy makers in reshaping education systems accordingly. As of mid-2022, experts believed AI could answer about 80% of the PIAAC literacy questions and solve around two-thirds of the numeracy test. There has been a significant increase in AI's literacy capabilities since 2016, due to advancements in natural language processing and the introduction of pre-trained language models like GPT. However, numeracy capabilities are believed to have changed less between 2016 and 2021. Despite this, **experts expect that AI will be able to solve the entire literacy and numeracy tests by 2026 due to the rapid technological advancements and heavy investments in natural language processing and AI models fine-tuned for mathematical problems**. The AI's potential performance in literacy and numeracy is close to that of adults. The report concludes that rapidly advancing AI capabilities in literacy and numeracy could **significantly impact employment and education**, as these skills are commonly used by most workers. This suggests a need to **shift the focus of education towards teaching students to use AI systems to perform literacy and numeracy tasks more effectively**.

Lane et al. (2023), provide a comprehensive understanding of the actual **impact of AI in workplaces** by surveying employers and workers in the manufacturing and finance sectors across seven countries (Austria, Canada, France, Germany, Ireland, UK and US). These are the key findings:

- **Positive Impact of AI:** The study shows a positive perception of AI among workers and employers, with 80% of AI users stating that AI improved their work performance. There is a substantial indication that AI enhances working conditions and contributes to higher productivity and better job quality.
- **Job Loss Concerns:** Despite the positive perception, there is a certain level of concern about AI-induced job loss. In firms that had adopted AI, 15%-20% of workers acknowledged that they knew someone who had lost their job due to AI. Further, 14%-19% of workers expressed fears about job loss in the next ten years.
- **Wage Pressure:** Many workers expected AI to put downward pressure on wages, with twice as many workers expecting AI to decrease wages in their sector in the next 10 years than those who expected an increase.
- **Task Reorganization:** AI led to a significant task reorganization, with 66% to 72% of employers in finance and manufacturing reporting that AI automated tasks workers used to do. Interestingly, AI has also created tasks not previously done by workers.
- **Skills Changes:** AI adoption led to significant skills changes and employers are addressing this through retraining or upskilling internal talent. More than 70% of workers expressed enthusiasm about learning more about AI.
- **Worker Consultation:** Outcomes are better in workplaces where workers or worker representatives are consulted regarding new technologies.

- **Trust and Data Privacy:** While most workers trust their employers to make the right decisions about AI, concerns around data privacy and AI's role in personnel decisions (like hiring and firing) were prevalent.
- **Barrier to AI Adoption:** Employers perceived cost and lack of skills as greater barriers to AI adoption than government regulation.

Green and Lamby (2023) provide cross-country insights into the AI workforce across OECD nations. The AI workforce is defined as **individuals with skills in statistics, computer science and machine learning who are capable of actively developing and maintaining AI systems**. Key findings from the study include:

- **Size of AI Workforce:** The AI workforce across OECD countries is relatively small, accounting for less than 0.3% of total employment. However, it is growing rapidly.
- **Demographics of AI Workforce:** The AI workforce tends to be primarily male and tertiary-educated and over 60% has at least a tertiary degree. Among the top ten occupations most demanding of AI skills, this figure rises to 80%. Women make up less than 40% of the AI workforce, compared to over 50% of the employed population with a tertiary degree across OECD countries. Approximately 50% of the AI workforce earns above the 80th percentile. However, the AI workforce is comparable to the overall employed population with a tertiary degree in terms of age and foreign-born status.
- **AI Skill Acquisition:** The AI workforce does not seem to disproportionately depend on adult learning for skill acquisition. AI workers are just as likely as other tertiary-educated workers to have engaged in training within the last month and when they do train, the focus is not specifically on digital or technical subjects that would enhance their AI skills.
- **Demand for AI Workforce:** Demand for AI workers is strong. Employment and average weekly hours growth for the AI workforce far exceeds that of the overall workforce. Wage growth for the AI workforce has been in line with that of the overall workforce, indicating that countries may be successfully meeting the demand for AI skills.

The authors' findings emphasize the importance of **cultivating a diverse and skilled AI workforce** for the successful development and deployment of AI. As the AI systems partially reflect the data and model choices of its developers, a diverse AI workforce can **contribute to the creation of AI that is equitable and beneficial for all of society** (Green and Lamby, 2023).

Considering almost one hundred case studies of AI implementation from the manufacturing and finance sectors across eight OECD countries, Milanez (2023) investigates **how AI influences workplaces, jobs, productivity and worker well-being**. The key findings of the study are as follows:

- **AI Impact:** AI technologies impact a variety of tasks and workers across firms and sectors. AI tends to automate routine tasks and is increasingly capable of automating non-routine tasks, which can affect workers across different skill levels.
- **Employment Levels:** Employment levels have remained steady overall, even with AI adoption and the report found limited evidence of AI-induced redundancies. There are instances where AI led to slowed job growth or job decreases, often managed through slowed hiring and attrition.
- **AI Skills:** There is a high demand for specialized AI skills, leading to job creation within the AI field. AI technologies require humans for development, training, updating and maintenance.
- **Job Reorganization:** The study suggests that job reorganization is more prevalent than job displacement. When AI automates certain tasks, demand for human workers to perform complementary tasks often increases.
- **Skill Requirements:** The implementation of AI often leads to higher skill demands and the need for broader skill sets, although in some cases, automation made certain skills redundant.
- **Job Quality:** From a worker perspective, the strongest endorsement for AI comes from its association with improvements in job quality. AI often leads to the automation of tedious tasks, increases worker engagement and improves physical safety. However, there are challenges, such as increased work intensity, stress related to learning new systems and concerns over greater monitoring.
- **Role of Policies:** Policies play a crucial role in shaping the impact of AI technologies. Social dialogue, training programs and fostering specialized AI skills can alleviate job loss anxiety and improve workers' willingness to engage with AI technologies.

The referred findings are examples and patterns rather than a definitive picture of how all firms or workers are impacted by AI technologies. However, **common themes emerged across the case studies**, suggesting that the findings may have **broader relevance**. The study also found a close alignment with the results of OECD surveys on the impact of AI in the workplace, indicating a consistent picture of AI's influence on the world of work.

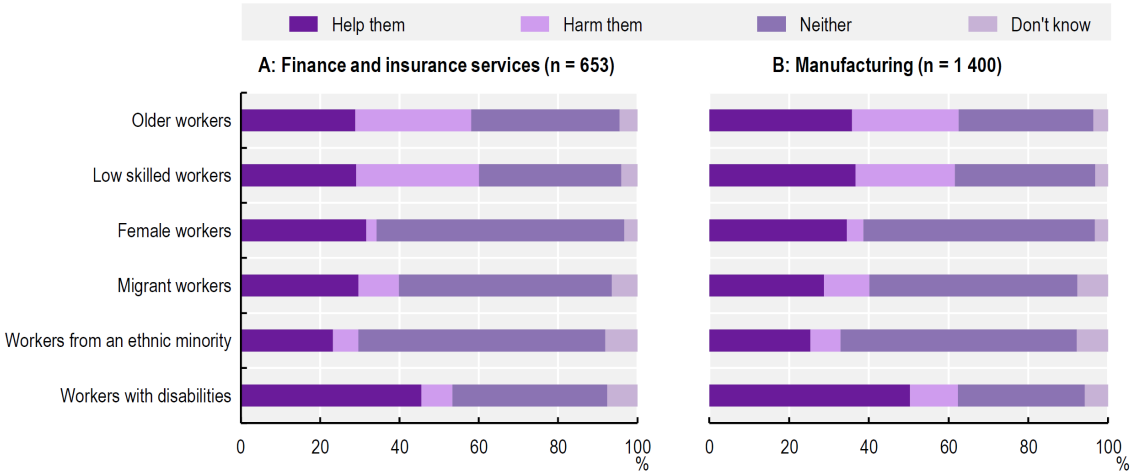
According to OECD (2023c), potential ramifications of the impact of recent breakthroughs in large language models and generative AI are **hard to quantify with present knowledge**. It is clear, nevertheless, that AI has the potential to render certain jobs redundant, pressuring workers to **acquire new skills or seek alternative employment**. The skills needed to develop, maintain and interact with **AI systems**, as well as **basic digital** and **data science** skills, will gain prominence. However, until now, AI has mostly effected changes in the roles and work environments, significantly affecting the quality of the jobs and the well-being of workers, with two different perspectives (OECD, 2023c):

- AI can automate hazardous tasks, enhancing **job satisfaction and safety** in certain risky jobs;
- On the other hand, workers might find themselves constricted to a decreasing array of simpler tasks, potentially leading to **wage depreciation or unemployment**.

Also according to the OECD (2023c), **so far, AI has had a greater impact on the quality rather than the quantity of work**.

Finally, the potential for AI to **impact the inclusiveness within the workforce** is perceived differently by employers and workers, according to the OECD AI surveys (OECD, 2023c). Notably, almost half of the employers in sectors like finance and manufacturing see AI as a **beneficial tool for workers with disabilities**. However, for **older and low-skilled workers, employers tend to hold a more negative view**, expressing concerns that AI may in fact adversely affect them. Interestingly, although employers generally believe that AI could benefit women more, **female AI users themselves exhibit less optimism** regarding the effect of AI on their job quality, compared to their male counterparts. This **perception persists even after adjusting for the different occupations held by male and female AI users**. Such findings prompt deeper consideration about the potential risk of certain workers being left behind as AI technology becomes more pervasive.

Perceptions of AI Impact on Different Demographics - Disparity between Employers and Workers (Percentage of all employers)



Source: OECD, 2023c

In conclusion, the impact of AI on jobs is a topic of intense discussion and research. It is a complex issue with **both positive and negative aspects**. On one hand, AI is expected to lead to **job displacement** in certain sectors, especially those involving routine or repetitive tasks that can be easily automated. On the other hand, AI is also expected to **boost productivity and create new jobs**, many of which we may not even be able to envision today.

4.4. Potential for Bias and Discrimination

According to the European Union Agency for Fundamental Rights (2022), "bias in algorithms appears, can amplify over time and affect people's lives, potentially leading to discrimination".

As previously referred, AI systems learn from data and if that data reflects biased human decisions or a skewed sample of the population, the AI **may also learn and perpetuate these biases**. This can lead to **discriminatory outcomes in various sectors**.

These sectors may vary but a study by Silberg and Manyika (2019) focus on the growing use of AI in sensitive areas, including for **hiring**, criminal **justice** and **healthcare**, stirring a **debate about bias and fairness**.

There are many **documented cases of AI systems demonstrating bias** and these are some examples:

- **Facial recognition system:** The case where a facial recognition system had higher error rates for darker-skinned and female individuals (ITRex Group, 2021);
- **Criminal risk assessment tool:** The risk assessment tool used in the criminal justice system, the COMPAS algorithm, was found to falsely flag African Americans defendants as future criminals at almost twice the rate as Caucasian defendants (McEvoy, 2023);
- **Healthcare algorithm:** The case of an algorithm used by healthcare providers to identify patients who would benefit from extra care was biased against African American patients (Shin, 2020);
- **Natural language processing:** An AI system that was being trained to understand natural language exhibited gender bias (Gow, 2020). The system was fed new articles that caused the AI to think, "Man is to Doctor as Woman is to Nurse";
- **Recruiting tool:** Amazon developed an AI recruiting tool that was biased against women (Dilmegani, 2022). The system was trained on resumes submitted to Amazon over a 10-year period, and "data contained biases against women since there was a male dominance across the tech industry and men were forming 60% of Amazon's employees".

The examples mentioned above illustrate that such biases are not confined to a particular sector, but can infiltrate **various aspects of society**, including law enforcement, healthcare, and the job market. The risks associated with these biases range from **perpetuating stereotypes and discrimination to making critical life-altering decisions based on flawed assumptions**. It underscores the pressing need for **transparent, fair and accountable AI systems**.

"The question of control and safety was paramount, of course, in any discussion involving potentially self-replicating machines."
Greg Bear, "Blood Music"

5. EU Policies on AI

This section dives into the intricate **landscape of the EU's policies and regulations** surrounding AI and aims to provide a comprehensive understanding of the current EU policies in place to regulate AI. Further, it will delve into the delicate **balancing** the EU is undertaking between **fostering AI development and enforcing stringent regulation** to ensure ethical AI practices. Finally, the focus shifts towards **Portugal, exploring the implications of these policies and strategies on the country's AI ecosystem**. By dissecting these areas, this section will offer an insight into how the EU's regulatory perspective on AI is influencing its position in the global AI landscape and impacting Portugal.

5.1. Existing EU Policies and Regulations on AI

The EU has been a **strong advocate for responsible and ethical use of technology**. When it comes to AI, the EU's approach emphasizes both **harnessing the technology's potential and managing its risks**.

The EU has adopted an approach towards AI that seeks to boost Europe's technological and industrial capacity, as well as AI uptake across the economy, while ensuring the respect of "**European values and rules**" (European Commission, 2020a).

This is encapsulated in the **European AI Strategy**, unveiled in 2018, which **lays out an ambitious plan for the EU to become a world-class centre for AI** (European Commission, 2018). Placing a strong emphasis on creating AI that is **human-centric and trustworthy**, the strategy embodies the European principles of **excellence and trust**. This strategic vision is operationalized through concrete rules and actions designed to foster a **robust, ethical and innovative AI landscape** in the region. The strategy not only seeks to accelerate the EU's technological advancements in AI but also ensures these developments are **aligned with the fundamental values and societal needs of its citizens**. The strategy proposes a three-branched approach:

- **Increasing public and private investments in AI to boost its uptake:** The EU has proposed to increase its investment in AI in both the public and private sectors.
- **Preparing for socio-economic changes brought about by AI:** The EU has emphasized the need to prepare for the socio-economic changes brought by AI and has called for a broad and inclusive discussion on its impact on our society.
- **Ensuring an appropriate ethical and legal framework:** The EU is dedicated to lead the work in setting ethical guidelines and is in the process of drafting AI ethics

guidelines that focus on issues like fairness, safety, transparency, the future of work, democracy and more broadly the impact on the application of the Charter of Fundamental Rights.

The European Commission's "**White Paper on Artificial Intelligence**" (European Commission, 2020a) sets out a policy framework to promote an "ecosystem of trust" and excellence in AI. This involves creating the right incentives to **foster the adoption of AI and addressing more broadly its impact on the economy, society and individuals** (European Commission, 2020a).

In April 2021, the European Commission proposed the **first-ever legal framework on AI**, marking a significant milestone in AI regulation, which **positions Europe to play a leading role globally**. The proposal follows a **risk-based approach** and lays down a uniform, horizontal legal **framework** for AI that aims to ensure legal certainty. The regulation proposal aims to ensure that AI systems are used in a manner that is **safe** and respects the existing laws, values and rights, while **fostering AI innovation and uptake** (European Commission, 2021a).

The proposed legislation sets a **risk-based approach** (European Commission, 2021a; European Commission, n.d.):

- AI systems are categorized based on the **potential risk they pose** - unacceptable risk, high risk, limited risk and minimal risk.
- **Unacceptable risk** applications are **prohibited**, while **high-risk** applications are "subject to **strict requirements** before they can be put on the market".
- **High-risk** systems include AI technologies used in "critical infrastructures, educational or vocational training, employment, essential private and public services, law enforcement, migration and administration of justice".
- For AI systems posing a **limited risk**, the legislation requires **transparency**. Users should be aware "that they are **interacting with an AI system, unless this is obvious** from the circumstances and the context of use".
- AI systems with **minimal risk**, like AI-enabled video games or spam filters, are **not subject to the proposed regulation**.

Recently, in a landmark move, the European Parliament (2023b) has **approved** (499 in favour, 28 against and 93 abstentions) the **first European Union regulations on AI**. This crucial development will now move to **negotiation with the Council to prohibit biometric surveillance and impose transparency on AI systems like ChatGPT**.

Recent information about the AI Act's state of play (European Parliament, 2023a) suggests that the following rules will apply **once it enters into force**:

- "The rules, as previously referred, follow a **risk-based approach**, establishing obligations for providers and users depending on the level of risk the AI can generate". Some AI systems are considered to have an unacceptable level of risk to people's safety and would be strictly prohibited. These include systems that use

"**subliminal or purposefully manipulative techniques, exploit people's vulnerabilities or are used for social scoring (classifying people based on their social behaviour, socio-economic status, personal characteristics)**".

- The legislation includes specific "**bans on intrusive and discriminatory uses of AI systems**", such as "real-time remote biometric identification systems in publicly accessible spaces", "predictive policing systems" and "emotion recognition systems in law enforcement, border management, workplace and educational institutions".
- **Providers of foundation models**, such as GPT, are required to "**guarantee robust protection of fundamental rights, health and safety and the environment, democracy and rule of law**". They need to "assess and mitigate risks, comply with design, information and environmental requirements and register in the EU database". **Generative foundation models** must "comply with additional **transparency requirements**, like disclosing that the content was generated by AI, designing the model to prevent it from generating illegal content and publishing summaries of copyrighted data used for training".
- The legislation **promotes AI innovation** by adding exemptions for "research activities and AI components provided under open-source licenses". It also **enhances "citizens' rights** to file complaints about AI systems and receive explanations of decisions based on high-risk AI systems that significantly impact their rights".

Nevertheless, the new rules might only come **into effect by 2025**, given the necessary **adaptation time**.

Additionally, the EU has been actively working to **establish robust liability frameworks** for AI systems, namely based on the "Report on Artificial Intelligence Liability" (European Commission, 2020b). This endeavour is particularly important given the unique **challenges that AI poses to existing liability rules**. The goal is to provide individuals harmed by AI systems with the "**same level of protection as those harmed by other technologies in the EU**".

In October 2020, the EU adopted a legislative resolution on civil liability for AI, based on Article 225 of the Treaty on the Functioning of the European Union (European Parliament, 2021). The resolution requested the European Commission to propose **appropriate legislation to address the liability issues associated with AI**.

The European Commission responded to the Parliament's request and the objectives of the White Paper on AI by publishing a **proposal for an "Artificial Intelligence Liability Directive"** in September 2022 (European Commission, 2022). The proposed directive aims to enhance the functioning of the internal market by establishing uniform rules for certain aspects of non-contractual civil liability related to damages caused by AI systems.

This comprehensive strategy is aimed at ensuring that victims who suffer damage to their life, health or property because of new technologies, including AI, have access to the same compensation as victims of other technologies (Wendehorst, 2022b).

The directive, however, has been met with **scrutiny from stakeholders and academics alike**, who question its **effectiveness, adequacy and potential impact on innovation** (European Parliamentary Research Service, 2023; Wendehorst, 2022a). Concerns have also been raised about its **coherence with the AI Act** currently under negotiation and the interplay between EU and national rules (European Parliamentary Research Service, 2023).

However, the **initiative is ongoing** and as the AI landscape continues to evolve, so will the EU's approach to addressing the associated liability issues.

The AI Liability Directive proposal is **just one part of the larger package of measures addressing AI that includes the AI Act**.

Finally, the **GDPR** (European Parliament, 2016), enacted by the EU, plays a significant role in EU's approach to AI. The GDPR, which primarily addresses **data privacy and protection**, is an integral part of the EU's AI framework. It offers a set of guidelines that any **AI system operating within the EU must adhere** to, ensuring that data collection, storage and processing practices follow strict privacy standards. Moreover, GDPR's principles, such as transparency, data minimization and purpose limitation, **directly affect the design and operation of AI systems**. The EU, therefore, encourages the development of **AI systems that respect user privacy and enforces accountability**, making it a crucial component of the EU's efforts to set ethical standards for AI development and deployment globally.

The EU's regulations and policies on AI demonstrate a commitment to a **human-centric approach** to AI.

Overall, the European Union is making a concerted effort to move from a voluntary to a **regulatory approach in AI governance**, introducing additional requirements to mitigate risks and enforce human supervision and clear communication about AI capabilities and limitations.

5.2. EU's Approach to Balancing AI Development and Regulation

According to Engler (2023), the **EU and US have divergent approaches to AI regulation**. The **EU** has taken a more **prescriptive** approach to AI regulation, while the **US** has taken a more **permissive** approach.

Notwithstanding, the EU has been strategically focusing on fostering a regulatory environment that **encourages AI development** while ensuring the use of this technology is **safe and respects fundamental rights**. It seeks to strike a **delicate balance** between mitigating risks associated with AI and fostering a positive environment for AI innovation and adoption.

The EU's approach to balancing AI development and regulation can be encapsulated in its vision to achieve both an "**ecosystem of trust**" and an "**ecosystem of excellence**". This

dual approach, outlined in the EU's White Paper on AI (European Commission, 2020a), seeks to **promote "the uptake of AI" and address the "risks associated with certain uses of this new technology"**:

- **Ecosystem of Trust:** The "ecosystem of trust" refers to the EU's commitment to ensuring that AI applications respect European laws, values and rights. To this end, the EU has proposed legislation categorizing AI systems based on their risk, with varying levels of regulatory oversight applied to each. This way, the EU intends to ensure that AI systems are lawful, ethical, robust and adhere to strict privacy and data governance requirements. The aim is to prevent harm to rights, safety and interests of individuals and society while maintaining public trust in AI technologies.
- **Ecosystem of Excellence:** The "ecosystem of excellence" refers to the EU's plan to bolster AI research, development and innovation. This includes facilitating the creation of digital innovation hubs, investment in AI-focused R&D and efforts to attract talent. Moreover, the EU also aims to promote the use of AI across businesses, especially SME and public administrations.

The EU's approach is thus **not to over-regulate AI**, but rather to create a regulatory environment that strikes the **right balance between fostering innovation and ensuring the technology is used responsibly**. This balanced approach aims to maximize the benefits of AI while minimizing its risks, fostering public trust and ensuring Europe's competitiveness in the global AI landscape.

Considering the policies and regulations presented in the beginning of this chapter, the challenge for the EU is to continuously **adapt its regulations to keep pace with the rapid advancements in AI while not stifling innovation**, by adopting:

- **Risk-based approach:** The risk-based approach means that the regulations are not uniformly applied to all AI systems but rather depend on the potential harm they might cause to individuals or society.
- **Technologically neutral policies:** The EU ensures its AI policies are technologically neutral. The goal is not to restrict any technology but to address potential risks and ensure ethical and responsible use. This encourages developers and companies to find innovative solutions that respect the principles of privacy, transparency, accountability and human oversight.
- **Investment in R&D:** The EU promotes investment in AI research and innovation in its 2021-2027 budget as part of the Digital Europe and Horizon Europe programs. The EU's Coordinated Plan on AI aims to create synergies and joint actions for the benefit of all member states.
- **Environment of Trust:** The EU is taking active steps towards creating an environment of trust. The AI regulations are seen as a tool to foster public trust in AI systems, thereby encouraging their adoption. By promoting a culture of

compliance and ethical use of AI, the EU aims to reassure the public and stakeholders that AI systems can be used safely and beneficially.

In conclusion, while **promoting AI development and deployment**, EU's regulations and policies also **prioritize protecting human rights, privacy and ensuring transparency and accountability** in AI systems.

5.3. Implications for Portugal

The EU's policies and regulations on AI are designed to create a framework where AI can be **developed and used in a trustworthy, ethical and human-centric manner**. These regulations have a significant **impact on all member-states**, including Portugal. Additionally, **GDPR laws may also interact with the new AI regulations**. The GDPR has already set a precedent for national-level implementation of EU regulations on digital technologies and it is likely that similar processes will be used to incorporate the AI Act.

Regarding AI, Portugal already has a **comprehensive strategy**. The Portuguese AI National Strategy, released in 2019 (INCoDe.2030, 2019), was designed to consolidate Portugal's role as a competitive player in the global digital economy by leveraging AI capabilities. The strategy aims to **encourage economic growth, modernize public administration, foster inclusivity, promote sustainability and enhance scientific research and technological development**. The Portuguese AI National Strategy articulates its vision through five axes, which are interconnected and reinforcing, set out a comprehensive roadmap to harness the benefits of AI for the Portuguese economy and society – **Inclusion, Education, Qualification, Specialisation and Research**:

- The **Inclusion** axis is aimed at promoting **digital inclusion** by developing the necessary competences to understand and handle the risks and opportunities induced by Digital Transformation and particularly AI. This involves nurturing digital autonomy, understanding privacy and safety concerns and promoting community awareness and cooperation;
- The **Education** axis emphasizes the importance of an **education strategy** that includes early introduction of fundamental concepts of computer science complemented by ICT learning integrated into the curriculum of other disciplines. Concepts of AI are considered at an early stage of schooling to provide young students with a solid grounding in digital problem-solving, creative thinking and risk awareness in cyberspace;
- The **Qualification** axis recognizes the need for a **qualified workforce** to leverage the productivity growth potential of AI, involving professional training of both unemployed and active workers in ICT and AI, improving public services through a better qualified public administration and reskilling and upskilling professionals through advanced training programs in AI;

- The **Specialisation** axis highlights the role of **higher education** in preparing highly skilled professionals in fields related to AI, with the aim of keeping up with international standards and evolving industry demands. It also acknowledges Portugal's attractiveness for international high-tech companies and emphasizes the importance of nurturing this talent pool to address workforce shortages.
- The **Research** axis focuses on intensifying **AI research, developing advanced computing, addressing the challenges of data curation, ethics, transparency and accountability in AI**, promoting the transfer of technology and solutions to industry and services.

The EU's policies and regulations on AI can have several **impacts for Portugal**, both positive and negative:

- **Economic Impact:** If AI regulation encourages the responsible growth of AI industries, this could lead to job creation, economic growth and increased competitiveness for Portugal. However, if the regulations are too restrictive, they could stifle innovation and make it more difficult for Portuguese companies to compete on the global stage.
- **Trust:** EU's focus on creating an "ecosystem of trust" can help to introduce greater confidence in AI technologies in Portugal. This can lead to increased adoption of AI by Portuguese businesses and citizens, which can spur innovation and economic growth.
- **R&D:** The EU's policies to foster an "ecosystem of excellence" can potentially lead to more funding and support for AI R&D in Portugal. This can encourage the growth of Portugal's tech sector and make the country more competitive in the global AI landscape. For example, if the EU prioritizes ethical AI, then Portuguese researchers might focus more on developing algorithms that are transparent, fair and privacy-preserving.
- **Regulatory Compliance:** While EU regulations can help ensure that AI technologies respect privacy, safety and ethical standards, they may also impose additional burdens on Portuguese companies. Compliance with these regulations could require significant resources, particularly for SME.
- **Data Governance:** The EU's strict data privacy regulations can impact on how Portuguese companies collect, store and use data for AI applications. While these regulations can help protect the privacy of Portuguese citizens, they can also limit the types and amounts of data that companies can use for AI.
- **Job Market Shift:** The increased use of AI may lead to a shift in Portugal's job market. While jobs may be lost due to automation, new jobs could be created in AI development, data analysis and other tech sectors, highlighting the importance of Upskilling and Reskilling.

- **Education and Workforce:** The EU's policies may influence the skills that are taught in Portuguese schools and universities. For example, if the EU emphasizes the importance of AI literacy, then Portuguese educational institutions might incorporate more AI-related topics into their curriculums.
- **Legal, Social and Ethical Considerations:** The implementation of AI technologies may raise social and ethical questions in Portugal, such as how to ensure fairness in AI decision-making or how to protect against potential misuse of AI.
- **Privacy and Data Protection:** The EU's privacy and data protection laws may have a significant impact on how AI systems are designed and used in Portugal.

Overall, the EU's AI policies and regulations are likely to have a **significant impact on Portugal**. It is important for Portugal to **proactively engage with these changes** to maximize the benefits of AI and minimize potential risks.

However, the specific consequences for Portugal can be quite broad and depend on several factors such as the **state of AI development** in Portugal, the **nature of the AI applications** used or developed in Portugal and the **specific sectors** in which these applications are used.

Finally, the proposed AI Act by the EU aims to regulate AI technologies, ensuring they are ethical, transparent and compliant with fundamental human rights. This regulation, while crucial for responsible AI deployment, may pose **significant implications for businesses** (Gragousian, 2022), namely in Portugal. **Non-compliance with the AI Act could result in hefty fines, like those under the GDPR, urging businesses to reassess their AI systems and strategies**. While the Act would increase the overhead on all AI spending by an estimated 17%, businesses are prompted to validate the value of their AI systems, balancing the cost of compliance against the competitive advantage gained from AI deployment. Companies might be forced to evaluate whether their AI applications positively impact their KPIs and society, necessitating robust and thoughtful AI strategies. For businesses that demonstrate AI's significant value, the Act might indeed become an opportunity rather than a burden, promoting ethical and beneficial AI usage. However, **for small to medium-sized businesses, these additional obligations and costs could be a limiting**.

Undeniably, EU's AI policies and regulations have profound **implications on the development and application of AI in Portugal**, pushing for responsible, ethically-compliant, and value-adding AI practices. These regulations, while potentially **burdensome**, offer a valuable opportunity to set the gold standard in AI applications, striking a **balance between technological innovation and societal welfare**. To seize the benefits and mitigate the risks associated with AI, Portugal must foster a **proactive, collaborative and informed approach among all stakeholders**.

"The only way of discovering the limits of the possible is to venture a little way past them into the impossible."

Arthur C. Clarke, "Profiles of The Future"

6. Recommendations for AI Strategy in Portugal

Considering the **vast potential** of AI and its **rapidly expanding impact** on diverse sectors, it is crucial for Portugal to develop the following key recommendations:

- **Invest in AI Education and Training:** To prepare for an AI-centric future, Portugal should invest in AI education from primary to higher education, while also promoting vocational training, upskilling and reskilling programs for the existing workforce. Lifelong learning in AI is essential as emphasized by the European Commission's report on "Artificial Intelligence for Europe" (European Commission, 2018).
- **Promoting public awareness campaigns:** Public awareness campaigns play a crucial role in broadening the understanding of AI in society. They can be instrumental in dispelling myths and misconceptions, fostering a realistic understanding of the potential benefits and risks of AI and encouraging responsible use of AI technologies. These campaigns can be conducted in various forms, such as digital campaigns, workshops and seminar, collaboration with media, public demonstrations (showcasing), competitions and partnerships with educational institutions.
- **Promote R&D:** Portugal should encourage AI R&D through funding, creating partnerships with universities and private entities and establishing AI-focused research centres. This strategy aligns with the European Commission's "Coordinated Plan on Artificial Intelligence" published in 2018 and updated in 2021 (European Commission, 2021b).
- **Foster AI Startups and Businesses:** Portugal may support AI startups and businesses through tax incentives, grants and reducing regulatory hurdles, in line with the "AI Portugal 2030" National Strategy (INCoDe.2030, 2019). It is also important to create programs to connect startups with investors and to provide mentoring and guidance to new entrepreneurs in the AI area.
- **Ensure Ethical Use of AI (namely through an AI Ethics Committee):** Portugal should implement regulations to guarantee the ethical use of AI in accordance with the EU's AI Act. This entails transparency, traceability and non-discrimination in AI systems and guaranteeing human oversight. To oversee the application of AI ethics, Portugal could establish an AI Ethics Committee, broadening the spectrum of one of the recommendations included in the "GuIA - Guia para a Inteligência Artificial"

(Agência para a Modernização Administrativa, 2022). The AI Ethics Committee could be responsible for reviewing AI projects for potential ethical implications, giving guidance to AI developers and users and auditing AI systems for compliance with ethical principles and regulations. These ethics boards should have a diverse membership, including AI experts, ethicists, legal experts, representatives from civil society and public representatives, among others.

- **Protect Data Privacy:** Data privacy is critical in AI development. Portugal must ensure robust data protection laws that protect citizens' privacy, based on the EU's GDPR, while also enabling innovation.
- **Encourage International Collaboration:** Portugal should collaborate with other countries on AI policy, regulation and research to share knowledge, best practices and to stay updated on global AI developments, in line with OECD's "Recommendation of the Council on Artificial Intelligence" (OECD, 2022). This point is crucial given the global nature of AI development. Collaboration could also potentially involve partnering on specific AI projects or initiatives.
- **Dedicated Regulatory and Compliance Assistance:** Considering the new EU AI Act, Portugal should consider the creation of a dedicated body or task force in an existing body (e.g., Portugal Digital) focused on assisting Portuguese companies in navigating these regulations. This body could provide support and guidance to organizations, ensuring that they fully understand the new requirements and helping them to achieve compliance. The task force could provide resources such as training programs, best practice guides and consultancy services to aid companies in effectively meeting the regulatory obligations. By offering this support, Portugal could reduce the compliance burden on businesses, particularly for SME and encourage innovation and growth in the AI sector.

Finally, these are some of the areas in which Portugal could focus for AI development:

- **Digital Health:** Portugal can leverage AI in healthcare to improve patient outcomes, streamline administrative processes and promote R&D in medicine.
- **Smart Cities:** AI can be used to create more sustainable and efficient cities in Portugal. For example, AI can manage traffic flow, optimize energy usage and improve waste management.
- **Agriculture:** AI can help Portuguese farmers improve crop yields and reduce waste through predictive analytics and automation.
- **Education:** AI can be used to personalize learning for students in Portugal, adapt to individual learning styles and provide real-time feedback to teachers.
- **Tourism:** Portugal's tourism industry can use AI to create personalized travel experiences, optimize booking processes and provide virtual assistance.
- **Manufacturing:** Portugal's manufacturing sector can use AI to optimize production processes, improve quality control and predict maintenance needs.

- **Financial Services:** AI can be used in Portugal's financial sector to improve risk assessment, detect fraudulent transactions and personalize financial advice.

In conclusion, this is **an opportunity for Portugal to become a player in the AI domain** by leveraging its strengths and strategic advantages, such as its tech talent pool, digital infrastructure and startup ecosystem. By **developing a comprehensive AI strategy** that encompasses education, R&D, support for AI businesses, ethical use of AI, data privacy, international collaboration and focused development in key sectors, Portugal can **use the power of AI to drive economic growth, societal well-being and global competitiveness**.

"The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom."

Isaac Asimov, "Isaac Asimov's Book of Science and Nature Questions"

7. Final remarks

The emergence of AI has generated a **paradigm shift** in the global arena, affecting **numerous sectors** from healthcare to manufacturing, education to finance and beyond. This GEE Paper explored AI's **historic development**, its **present landscape**, the multifaceted nature of **AI applications**, inherent **challenges**, along with a dive into the **regulatory landscape** framed by the European Union and its **implications** for Portugal, creating a holistic narrative around AI. This broad analysis enabled us to construct a **comprehensive perspective** of the AI ecosystem and propose strategic **recommendations** for Portugal's AI.

However, like any study, ours is **not without limitations**. The fast-paced and evolving nature of AI means that some of our analysis could become less relevant or obsolete as **new developments arise**. Further, this study has focused on a strategic and regulatory perspective and while we have endeavoured to offer a holistic view, **some areas may need deeper investigation**.

These limitations highlight areas for future research. Studies could explore more **sector-specific strategies for AI implementation in Portugal**, delve into **case studies of successful AI application** or examine the **societal and cultural factors** affecting AI adoption within Portugal.

In the subsequent sub-chapters, we will summarize the **core insights** from our review of AI and we will **project the potential trajectory**, extrapolating from our **current understanding** of global AI trends and regulatory evolution and from the **strategic recommendations** we proposed.

It is essential to remember that the landscape of AI is **continuously changing**, shaped by technological advances, regulatory decisions and societal responses. Understanding and leveraging **AI's potential**, while **mitigating its risks**, requires ongoing commitment, adaptability and research.

7.1. Summary of Key Findings

This GEE Paper has charted the complex landscape of AI regulation and strategy within the European Union and, in particular, Portugal. Here, we highlight our key findings:

- **AI's Potential:** AI technologies have significant potential to drive productivity and innovation across diverse sectors such as healthcare, agriculture, education,

tourism and manufacturing. Its transformative potential offers Portugal numerous opportunities for economic development and social progress.

- **European AI Regulation:** The European Union's AI Act is a comprehensive regulatory framework that prioritizes human rights, privacy and transparency in the development and deployment of AI systems. It represents a commitment to balancing technological innovation with ethical considerations and societal values.
- **Portuguese AI Strategy:** The "AI Portugal 2030" National Strategy and the European Commission's "Coordinated Plan on Artificial Intelligence" both reflect Portugal's commitment to AI. Despite this, there is room for a more robust, comprehensive and forward-looking national AI strategy.
- **Academia-Industry Collaboration:** Portugal is home to some important tech companies and has a strong academic sector. Enhancing the connection between these two could foster greater AI innovation and competitiveness and result in the creation of a robust ecosystem that allows Portugal to emerge as a player in the AI landscape.
- **Skilling and Reskilling:** Recognizing the rapid pace of AI advancement, the imperative of skilling and reskilling workforce for AI-readiness is undeniable. A long-term strategic focus on skills development and continuous learning can equip Portugal with a future-ready workforce, able to employ and contribute to AI innovations.
- **Talent Retention and Development:** Portugal has a wealth of talent, which is key to the country's AI development. However, it is crucial to create an attractive ecosystem that not only cultivates this talent but also retains it. Too often, bright minds emigrate to seek opportunities elsewhere. Therefore, Portugal should focus on nurturing, retaining and attracting talent through incentives, opportunities for growth and a robust and innovative AI ecosystem.
- **Need for AI Education and Public Awareness:** Education and public awareness campaigns about AI's importance and impact are crucial. Additionally, the ethics in AI also involves the education of the programmers. These would cultivate a tech-savvy workforce, help the public understand AI's implications and foster an environment conducive to AI innovation.
- **Ethical AI Use and Data Privacy:** Portugal should implement robust regulations that guarantee ethical AI use and data privacy, as well as creating an ethics committee to promote compliance with EU regulations on this subject.
- **Importance of R&D and AI Startups:** To ensure long-term, sustainable growth in AI, Portugal should invest in AI R&D and support AI startups and businesses.
- **International Collaboration:** Global cooperation on AI policy, regulation and research is crucial for Portugal to stay informed of global AI developments and learn from international best practices.

These findings point to an exciting yet challenging journey for Portugal as it navigates the **transformative wave of AI**. To harness this technology's potential and ensure its responsible and ethical use, Portugal will need to **continually adapt and evolve its AI strategy in response to ongoing developments and challenges**.

7.2. Future Outlook

As we look towards the future, the role and impact of AI in our society will continue to evolve and expand. The potential of AI to replicate or even surpass human intelligence, as proposed by Turing in the mid-20th century, is still a **topic of considerable discussion**. These discussions **influence the development and application of AI** in the digital economy, shaping how AI is integrated into various sectors (Anyoha, 2017).

While the promise of AI is undeniable, it also **presents challenges** that must be addressed. Balancing the rapid advancements in AI technology with **ethical considerations and societal impacts** will be an ongoing task for policymakers and stakeholders alike.

Finding the **balance between laissez-faire and excessively stringent regulation is a delicate task**. **Excessive regulation** can stifle innovation, hinder economic growth and prevent the realization of AI's full potential. Conversely, **insufficient regulation** can lead to misuse or abuse of AI, with potentially serious ethical and societal consequences. It is therefore essential to cultivate a regulatory environment that **ensures the ethical use of AI and protects data privacy, but also allows AI technologies to grow and evolve**.

AI's future depends not only on how EU **regulations and policies** evolve but also on its people – the end-users, creators and overseers of AI systems. To ensure an **AI-literate population** capable of navigating this new digital landscape, ongoing investment in AI education, training and public awareness campaigns is crucial. At the heart of these endeavours, **international collaboration will play a pivotal role**. As AI transcends geographical boundaries, global cooperation can facilitate shared learning and create unified standards.

Finally, we are in a critical moment and **trustworthiness, transparency, and explainability** in AI are essential.

Establishing **trust in AI systems is complex and nuanced**. There is an important distinction between systems that are **technically trustworthy but may not earn people's trust**, and those that are **not trustworthy but manage to earn people's trust** anyway. This paradox highlights the intricate relationship between technology, human perception and our propensity to trust. In some cases, explainability (the ability to understand and interpret an AI's decision-making process) can be enough for users to feel comfortable trusting a system. However, an explainable system is not necessarily a good or ethical one. On the other hand, a system can be technically robust and ethical but might not be transparent or interpretable enough for users to trust.

An equally challenging question is the **certification of AI systems as trustworthy**. If an external entity is to provide a **stamp** of trustworthiness, determining **which entity** should have that authority and how it should evaluate AI systems are **complex issues**. This could involve a diverse group of stakeholders, including regulators, industry experts and representatives of the public. This underscores the need of a body such as an **ethics committee** to address such challenges.

7.3. The Role of Humans in the Age of AI

As we stand at the threshold of a future where machines might undertake a multitude of tasks currently performed by humans, **we are faced with profound questions**. What will be the **role of human beings** in a world where AI systems can handle complex tasks, from manufacturing to healthcare, from education to agriculture? What will **work look like** for us and **what will we do** when machines can do so much?

Yet, it is crucial to remember that AI and other technologies are tools that we have created. Their purpose is to **augment human capabilities, not to replace them**. While AI can analyse vast amounts of data, make predictions and automate tasks, it **lacks the inherently human qualities of empathy, creativity and the capacity for ethical judgment**. These qualities are and will remain, unique to humans, providing value that AI cannot replicate.

The future calls for us to redefine our role. It presents an **opportunity for humans** to engage more fully in the uniquely human aspects of work and life. To create, to think critically, to empathize and to make ethically sound decisions. As machines take on more repetitive and data-intensive tasks, we might find more time to engage in creative pursuits, in-depth research and innovative problem-solving. It may lead to a societal transformation where we **redefine what is meaningful work and a fulfilling life**.

In conclusion, it seems appropriate to quote the renowned computer scientist, Alan Kay, who said, "**The best way to predict the future is to invent it**". As creators of AI, we possess the power to shape its trajectory and its role in our lives. Let us use this power wisely, to **create a future where humans can benefit of the best that AI has to offer.**

And as we step into this future, let us remember the words of Carl Sagan, "**We are the custodians of life's meaning**". It is not just about the role we will play in an AI-driven world, but also the meaning and purpose we'll find in our lives and work in an increasingly automated world.

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