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# Artificial Intelligence: Economic Impact, Opportunities, Challenges, Implications for Policy

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**Abstract**

This discussion paper presents the key features of Artificial Intelligence (AI), highlighting the main differences with respect to previous IT and digital technologies. It presents the most relevant facts about AI diffusion across EU countries, and discusses the main economic implications, focusing especially on its impact on productivity and labour markets. While AI presents a formidable opportunity, it also entails major challenges, with implications for policy. This paper focuses on policies to remove bottlenecks to AI development and adoption, regulatory policies, competition policy, policies to deal with labour market and distributive implications.

**JEL Classification:** O30, J20, J30, O40.

**Keywords**: artificial intelligence, labour markets, productivity.

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# 1. INTRODUCTION

The present paper discusses economic opportunities and challenges from recent advancements in AI and presents the main questions for policy. While discussions on AI are taking place all over the media, there seems to be some confusion on what AI encompasses. AI is a broad term which gathers a wide variety of systems and applications. While predictive AI models (helping for instance the profiling of customers by predicting their tastes) have been in use since the first half of the 2010s, applications of generative AI models (whereby AI helps solving many types of problems formulated by the user in potentially many ways, for instance by generating code, text, images) are more recent. Thus, the paper provides key definitions that help understand AI as a technological phenomenon, together with an indicative timeline of the major developments in the field of AI. The paper also describes the role of data and hardware, as they act as enabling factors of AI development.

Despite the wide echo in the media, AI diffusion and actual AI adoption remain so far confined to few sectors and mainly large firms. While lags in the data are likely to explain part of this gap, this paper shows that AI adopters tend to be a minority of firms and, often, with specific characteristics. Namely, these firms are relatively large and concentrated in a few sectors. However, following the latest innovations which make the use of AI tools more user friendly, AI adoption may start spreading fast.

Potential productivity improvements associated with AI are considered long-lasting. A wide adoption of AI innovations has been estimated to increase GDP by as much as 7% over a 10-year period (Goldman Sachs, 2023a), however the evidence so far reveals positive yet not impressive gains, which may be due to the complex nature of the phenomenon. Empirical studies face limitations, as they tend to focus on a narrow set of tasks or occupations and may be capturing only part of the gains associated with AI. AI is developing at a fast pace, with innovations in machine learning, neural networks, and computational power, along with the exponential growth of data and cross-disciplinary applications, continually reshaping its capabilities. This dynamic evolution makes evaluating AI a moving target. Hence, past estimates are not necessarily representative of the future.

In the short-run, AI is likely to impact labour markets in broadly analogous ways to those of other digital innovations, but the effects could be quite different over the medium to longer term. In the short to medium term, AI has the potential to act as a productivity tool for workers, assisting rather than replacing them, potentially allowing for more efficient and effective job performance. Although AI may reduce the number of workers needed for specific tasks, there would still be a need for individuals to oversee AI operations and provide expert knowledge to ensure and exploit their effective use. Therefore, labour with the skills needed to adopt and implement AI solutions could gain, while the workers performing jobs with a high share of routine tasks are at risk of being substituted by AI. However, over the medium to longer term, depending on how fast AI solutions spread and develop, generative artificial intelligence could potentially substitute also skilled labour performing non-routine tasks. Over this horizon, there could be innovations replacing workers with cognitive skills and expertise on a potentially large scale, thus impacting their relative employment and earnings prospects. Moreover, the overall increase in productivity and income associated with AI could boost overall demand with positive implications for employment, reaching sectors not directly affected by AI.

AI raises a number of questions for policymakers. The first question is how to remove existing barriers to the adoption and deployment of AI. Due to knowledge spillovers and externalities, the net benefits of AI adoption from a social viewpoint is higher than that perceived individually by each firm, thus making AI a case of interest for public intervention. Second, regulatory gaps relating to AI need to be filled, notably for what concerns intellectual property, privacy, and human rights, while addressing the implications of AI for democracy, economic security, and the geopolitical context. Third, new issues for competition policy need to be tackled. These issues arise from the impact of AI on industrial structure and firms' behaviour. Finally, policy must cope with the possibly wide-ranging implications of AI on labour markets, ensuring not only adequate supply of skills and fair working conditions, but also managing the implications for the distribution of income over the longer term, as well as for taxation systems and fiscal stability.

The remainder of the paper is structured as follows. Section 2 provides the main definitions and breakthroughs in the field of AI, together with some estimates of AI adoption. Section 3 discusses the economic implications of AI, with a focus on productivity and labour markets, while section 4 presents policy approaches to deal with AI and section 5 concludes.

# 2. AI DEFINITIONS, DIFFUSION, USE

## 2.1. AI: MAIN DEFINITIONS

AI is broadly defined as a machine's ability to perform functions that are usually associated with the human brain.[1] While AI has been around since the 50s, today's AI systems are qualitatively different and capable of performing a wide range of functions.[2]

- AI systems from the early 2010s can make complex predictions based on past trends and observed patterns. This type of AI systems is customarily referred to as "predictive AI" and comprises applications such as those used to profile firms' customers or web users, and proposes tailor-made solutions based on a prediction of preferences.[3]
- More recent models became popular in the early 2020s following the launch of ChatGPT (November 2022) and are commonly referred to as "generative AI".[4] These models, in addition to making predictions, can generate content in response to questions posed by the users. Generative AI can perform tasks which have been considered specific to humans until now, such as ideation, writing, background research, coding, data analysis and math.
- Artificial general intelligence (AGI) is a broad concept referring to a stage of development of AI where AI would be capable to perform a wide range of cognitive tasks with similar or better results than humans.

AI systems stand on three building blocks: (i) AI models, (ii) data and (iii) hardware. Developments taking place in each of these building blocks allow AI systems to achieve stronger performance. On top, developments in each of these blocks enhance feedback loops on the others, thus reinforcing the pace of progress. For instance, more powerful hardware allows to run more complex models. In turn, better models allow humans to produce more output data, which might be used as input data, thus improving the performance of the model, and so on.

### Models

The evolution of AI models over the past 30 years has been exceptionally fast.

- AI models have been learning complex patterns from data since the early 2000s. Machine Learning is a branch of 'predictive' AI that develops models (algorithms) which can learn from/train on data. Models learn to classify (e.g., if an email is spam), predict (e.g., revenue projections), identify clusters (e.g., based on similarities between observations), make associations (e.g., movie suggestions) or reduce dimensionality (e.g., improve picture quality).

[1] (OECD, 2023) relies on the following definition 'an AI system is a machine-based system that for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments. Different AI systems vary in their levels of autonomy and adaptiveness after deployment'.

[2] For an extensive compilation of AI-related terms, please also refer to the work of (Estévez Almenzar, Fernández Llorca, Gómez, & Martinez Plumed, 2022). Their paper provides a concise yet inclusive collection of terms to aid AI researchers, practitioners, and policy makers in establishing a shared understanding of AI concepts.

[3] This type of AI can also be referred to as 'analytical', 'traditional', 'pre-Generative' or 'discriminative' AI.

[4] ChatGPT reached 100 million users just two months after launching, making headlines as the fastest growing app of all times.

The models are trained on a training data set; their performance is then checked and fine-tuned on a validation data set; and, finally, they are verified on a test data set to determine their real-world applicability and effectiveness.

- 2010s models understand more complex patterns, thanks to the introduction of 'brain-like' neural networks. Deep Learning is a type of machine learning based on a brain-like neural network architecture, with more than 3 layers of neurons. Each neuron receives inputs from the neurons in the previous layer and produces an output that is fed to the neurons in the next layer. This way, the neurons in each layer learn increasingly complex patterns. Each inter-neuron connection has a certain strength, called 'weight'. In 2014, generative adversarial networks (GANs) transformed the way AI learns to replicate complex patterns. GANs rely on two neural networks which improve through a form of internal competition: a 'generator' network that creates imitation data and a 'discriminator' network that disentangles real content from the imitation. This interaction encourages the 'generator' to produce increasingly accurate and convincing imitations, while the 'discriminator' becomes better at identifying discrepancies. Over time, this competition drives both networks to improve their performance.
- 2020s models get smarter by the day and 'generative' AI starts emerging. Generative AI builds upon GANs, but also Transformers – 2017, which constituted a major break-through. Transformers are a type of neural network architecture, which learns from paying attention to 'context' (e.g., in text, transformers consider the entire paragraph rather than just the word before or after). Transformers have a special capacity to scale up the performance of AI models by increasing their complexity, which results in adding more parameters. Parameters are the elements of the model that determine the mapping between the model's input and output and are learnt from data. In Generative AI models, these parameters are frequently represented by weights in neural networks that the model fine-tunes during training.
  - In 2006, AI models had max 100 million parameters,
  - In 2020, around 200 billion (e.g., GPT 3.5, ChatGPT released in Nov. 2022 was built on the AI model GPT3.5).
  - More recente models are said to report a number of parameters in the order of 1.2/1.6 trillion.

ChatGPT (OpenAI) and Gemini (Google) are two examples of recently released generative AI systems which are based on foundational models. Foundational AI models are trained to serve different purposes, as they are not fine-tuned to one specific use. For example,

- Large Language Models (LLMs) are foundational models (pre-)trained on (massive amount of) text data, while
- Vision Transformers (ViTs) are models pre-trained on extensive image datasets, allowing them to understand and interpret visual information.

In addition, GPT4 (OpenAI) and Gemini (Google), are multimodal models, as opposed to unimodal models. Unimodal models (most AI systems) process one type of data at once, e.g., text or images, while multimodal models can process multiple types of data at once, e.g., text and images.

### Data

Big data is both input and output of AI. Big data is characterised by (i) volume (large size and amount); (ii) variety (different types of data e.g., video, text etc.); and (iii) velocity (continuous data flows). AI also contributes to 'creating' big data, as AI systems are estimated to be quite prolific and produce output which might then be used as input data, thus, improving the learning of the models. AI models can learn on labelled or unlabelled data. Unlike unlabelled data, labelled data comes with known information, often added by humans. For example, in the case of images, this information could describe the content of the pictures, such as identifying if the image depicts a specific animal.

AI models that learn on labelled or unlabelled data have different strengths. Learning on labelled data is called supervised learning, while learning on unlabelled data is called unsupervised learning. Types of supervised learning are regression models, while unsupervised learning is often used for cluster-type analysis. As such, supervised learning tends to deliver more accurate predictions, but unsupervised learning requires little to no human intervention, which increases scaling potential and speeds up the data preparation behind the training process. ChatGPT is a good example of applying both methodologies. It is trained using supervised learning, where it learns from a dataset containing prompts and their corresponding responses. However, its initial pre-training phase involves unsupervised learning, focusing on predicting the next word in sentences, followed by a fine-tuning phase with supervised learning to enhance task-specific performance.

### Hardware

As AI models become more performant, they also become computationally more expensive and resource intensive. Since 2015, the compute power used by AI models has been estimated to double every six months (before 2010 it was every 20 months) – an acceleration in compute power implies that the performance of the models improves at a faster rate. For example, it is estimated that the training of an AI system such as GPT-4 might use up to 21 billion petaFLOP[5], while the training of an AI system in 2010 would have used around 61 petaFLOP, indicating a dramatic increase in the complexity and power required for contemporary AI training.

At the same time hardware is becoming more powerful keeping the pace with the growing computational needs of AI models. Several (rare material) chips are being produced specifically to optimise AI models and not all of them can be purchased publicly.[6] In addition to creating more powerful individual chips that can perform a greater number of operations per second for a given cost, the trend is also towards using multiple chips in parallel.

## 2.2. AI DEVELOPMENT AND ADOPTION

Regarding AI development, while big players are mostly located outside of the EU, e.g., US companies such as Microsoft and Google, some EU realities are establishing. For instance, Aleph Alpha and Mistral AI are two noteworthy cases. Aleph Alpha is based in Germany and focuses on developing large language and multimodal models, such as Luminous, targeting sensitive industries and governments. Mistral AI, based in France, focuses on enhancing the accessibility of AI through open-source initiatives. An example of this is their highly performant Mistral 7B and Mistral Large models.

European businesses are increasingly exploring the potential of AI.[7]

- Eurostat's 2023 survey on ICT usage in enterprises investigates the use of AI technologies among ca. 150 000 businesses with at least 10 employees. It finds that around 8% of EU businesses use at least one AI technology (up from 7.6% in 2021).[8] The OECD surveyed employers with at least 20 employees in the manufacturing and financial industries in four EU countries (AT, DE, FR and IE) as well as three peer countries (CA, UK and US) in 2022.[9] The survey finds that ca. 30% of this type of businesses (20+ employees) in manufacturing used AI,

[5] In the context of AI, training computation is measured using floating-point operations or "FLOP". Each FLOP corresponds to fundamental arithmetic operations, such as addition or multiplication, executed on two decimal numbers (Epoch AI, 2024).

[6] Some are: GPU Graphics processing units -most widely used; TPU Tensor Processing Units; NPU Neural processing units.

[7] Despite the technology's prominent position in the recent policy debate, the empirical work on AI's diffusion and adoption, in particular among smaller businesses, remains scarce. Even more, the evidence on AI adoption rarely offers an international perspective or allows for cross-country comparisons and few studies explore the characteristics of AI adopters or the barriers that non-adopters face.

[8] These technologies include autonomously moving machines, natural language generation, image recognition and processing, speech recognition, machine learning for data analysis, text mining and robotic process automation.

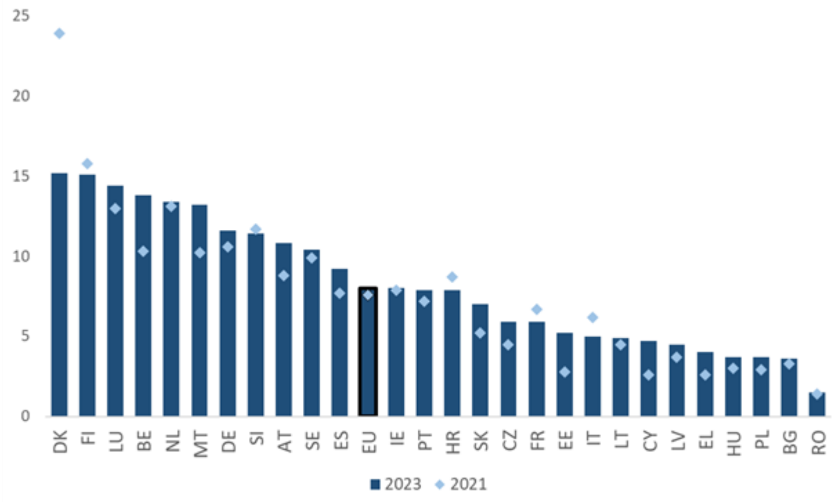
[9] By applying weights, the survey attempts to present findings that are representative of the underlying population of employers with at least 20 employees. Yet, the analysis excludes the many small firms with less than 20 employees, for which AI adoption is typically limited. For more information on the survey, see (Lane, Williams, & Broecke, 2023).

compared with more than 40% in finance.[10] In the US, ca. 6% of the 850,000 surveyed firms (incl. small businesses) in the Annual Business Survey (2018) use an AI-related technology.[11]

- Adoption rates of AI technologies (at ca. 8% of EU businesses with at least 10 employees) are typically lower than those of other digital tools such as cloud computing (ca. 40% of EU firms) or Internet of Things (ca. 30%).[12] However, available evidence suggests a remarkable acceleration in AI adoption in last decade.[13]

AI adoption differs strongly across countries and industries. The adoption rate of 8% among EU businesses in the Eurostat 2023 survey hides substantial differences across individual MS, ranging from 1.5% in RO to 15% in DK (Figure 2.2.1). Reasons behind these cross-country asymmetries include differences in the economy's digital performance and business environment as well as different availabilities of AI talent, digital skills, and big data. The differences between the four EU countries reported in the OECD survey for manufacturing firms are relatively small, ranging from 25% adoption among all German manufacturing firms to 32% in Ireland. AI uptake rates also differ strongly across sectors. Indeed, while AI is often considered as a general-purpose technology, its diffusion is particularly high in a subset of industries (Figure 2.2.2). Unsurprisingly, the ICT sector exhibits the highest share of AI users (close to 30%).[14] AI adoption is also high among enterprises in the professional services sector as well as in some high-tech manufacturing industries.

Figure 2.2.1 **Share (%) of enterprises (with at least 10 employees) using at least one AI technology – EU countries.**




Note: The drop between 2021 and 2023 registered for DK is explained by a change in the way the question was formulated.

Source: Eurostat survey (2023) on ICT usage in enterprises [isoc_e].

[10] These uptake rates are substantially higher than those observed by Eurostat, which in part can be explained by the exclusion of the many small firms with less than 20 employees, for which AI adoption is typically limited.

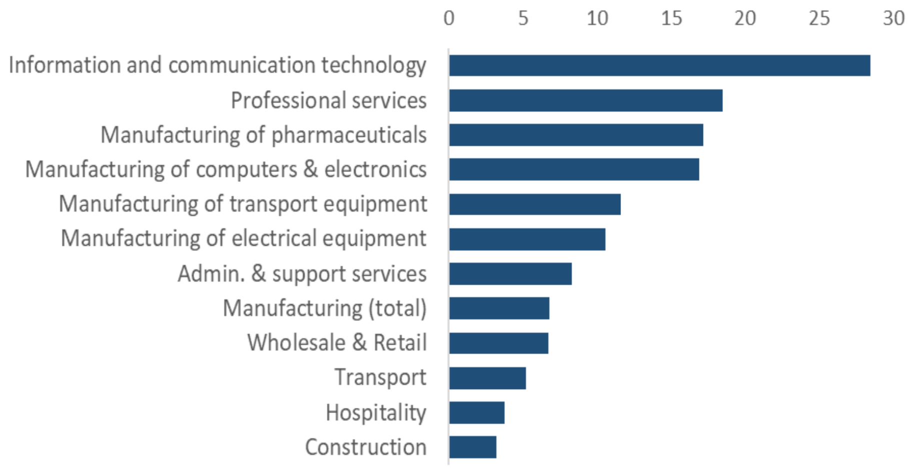
[11] See (McElheran, et al., 2024). This study This study aims to address the issue of underrepresentation of small businesses in surveys, by relying on the 2018 Annual Business Survey among US firms of all sizes.

[12] Eurostat ICT usage in enterprises isoc_e.

[13] For example, for the US a seven-fold increase in AI jobs is documented between 2010 and 2018 (Babina, Fedyk, He, & Hodson, 2024).

[14] Not only do many AI applications originate in the ICT sector, the high adoption rate in this sector may also hint at the importance of complementary intangible assets (e.g. expertise and skills, proprietary datasets and algorithms) in fostering AI technologies uptake and exploiting them more effectively.

Figure 2.2.2 **Share (%) of enterprises (with at least 10 employees) using at least one AI technology – EU industries.**




Source: Eurostat survey (2023) on ICT usage in enterprises [isoc_e].

The uptake of Artificial Intelligence is growing also in the public sector. AI technologies are of interest as AI can benefit various aspects of public service delivery, from personalised services to chatbots, as well as proactive services that reduce the administrative burden for citizens and businesses (Tangi, van Noordt, Combetto, Gattwinkel, & Pignatelli, 2022) (See Box 2.2.2). For instance, procurement professionals can be assisted by AI to process large volumes of data which are specific to each contracting action and public procurement alone accounts for around 13% of the EU's GDP. In light of the relatively large average public sector size in EU countries, AI adoption in public administrations provide a particularly relevant opportunity for productivity gains and fiscal savings across the EU.

Box 2.2.1 **AI USE CASES**

AI use cases span across several industries. The most common use cases include marketing, sales, customer services, as well as content generation. The functions which are horizontally applicable across industries include the generation of text, video etc., the automation of marketing tasks, and chatbots. However, some other functions tend to be more industry specific.

- In transport, the main uses of AI include self-driving cars, sensor technology and traffic prediction. Self-driving cars detect objects, make decisions, and navigate roads with little to no human intervention. Based on analytics, traffic patterns can be predicted, and parking optimised. Sensor technology can also be used in street lighting. Beyond cars, autonomous things which require no human direction, such as self-navigating drones, are currently used as support in logistics.
- In healthcare, AI is used in diagnostics, drug prescription, personalised treatment, and remote monitoring. AI automate some of the diagnostic process. For instance, AI analyses radiological images and detects abnormalities. AI algorithms also detect patterns based on data from clinical trials and scientific literature. In telemedicine, AI makes it possible to monitor patients remotely. In medical research, AI is used to simulate the chemical interactions needed to assess a drug's efficacy, thus helping with usually long processes, e.g., identification of vaccines.
- In finance, AI use cases include personalised customer service as well as risk and investment management. Thanks to AI, financial institutions provide personalised customer service and claim processes as well as tailored recommendations for products and services based on data. AI analytics is also used to manage risk, detect fraud, and prevent financial crimes. In trading, AI algorithms perform transactions in real-time, using pre-programmed rules.
- In manufacturing, some of the main uses of AI are in logistics and generative design. Concerning logistics, AI is used to predict maintenance and repair of equipment. In design, generative design software allows manufacturers to generate large numbers of design options for the same product. AI algorithms can also improve quality control and optimise supply chains based on data from different sources.
- In public administration, AI can be used to optimise service provision. For instance, in the case of public employment services, AI can screen resumes and identify the most qualified candidates for a job and help match job seekers with job openings by analysing their skills, experience, and preferences. Similarly, AI-powered chatbots can help citizens find information on job openings, training programs, and other services provided by public administrations.
- In education, the most noteworthy implications of AI include personalised learning and tutoring systems. AI can also be used in the grading process and to create educational content.

Box 2.2.2 **AI INITIATIVES IN MEMBER STATES**

The public administrations in some MSs have launched noteworthy AI applications. While a more comprehensive list is publicly available (Joint Research Centre (JRC), 2023), here we present a selection from (Tangi, van Noordt, Combetto, Gattwinkel, & Pignatelli, 2022):

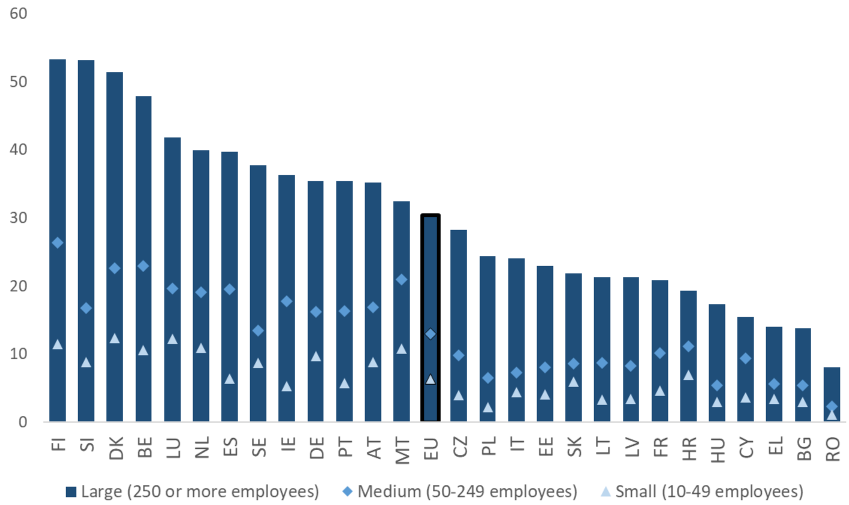
- Denmark: *Intelligent Control Platform*. A digital platform that provides an automated assessment of how a selected company/businesses is more likely to commit fraud compared with others.
- The Netherlands: *Object Detection Kit in the City of Amsterdam.* While no longer in use, the AI solution automatically identified rubbish on the street and shared this with the garbage management services of the city to act and solve the issue. This was done by analysing imagery collected from the pictures taken by smartphones.
- Belgium: *Reducing night noise through nudging in the Municipality of Leuven.* To solve an issue of too much noise in crowded streets, sound meters were installed and an application for citizens reporting developed.
- Luxembourg: *Unlocking digitised documents and correcting OCR.* The Luxemburg National Library developed an AI system that operates on top of the results of the different OCR (Optical Character Recognition) used over the years for digitising historical newspapers and books. The system aims at improving the quality of the result, identifying and correcting mistakes.
- Estonia: *OTT – decision support tool for consultants.* An AI system used in the Estonian Unemployment Insurance Fund which aims to assist its consultants with providing insights predicting the chances of an unemployed person getting a new job.
- Finland: *Automation of subtitling videos and audios.* The AI system is based on understanding speech and transforming it into text. It is used to provide subtitles on videos and is part of a wider initiative within the administration to use Speech-to-Text technologies in various use cases.
- Spain: *Estimation of income for those paying by modules.* An AI system which estimates the income of Small and Medium Enterprises (SMEs) as well as of self-employed individuals who have decided to pay their taxes in phases rather than defining an exact income.

AI adoption also varies substantially across firm size classes and is particularly concentrated among larger firms. The adoption rate of 8% among all EU businesses hides substantial differences across firms of different sizes, with uptake rates exceeding 30% among large firms (at least 250 employees) but only 6% among small firms (10-49 employees) (Figure 2.2.3). This skewed adoption among larger firms is found in most studies and countries. The OECD's 2022 employer survey on the impact of AI on the workplace also finds that larger employers are more likely to report AI use, which holds across the EU countries (AT, DE, FR and IE) covered in the survey and three global peers (CA, UK and US). Findings from the OECD's AI diffuse distributed micro-data project suggest that in all 11 countries considered (incl. BE, DE, DK, FR, IE, IT and PT) the share of AI users is highest in the largest size class (+250 employees) and typically twice as large as the share of AI users for the second-ranked size class.[15] Early AI use in the US is found to be concentrated among larger firms, with the majority of firms with more than 5,000 employees using AI.[16]

[15] The AI diffuse project relies on confidential and representative firm-level data in 11 countries, sourced from official surveys among firms with at least 10 employees on their use of ICTs. See (Calvino & Fontanelli, 2023a).

[16] See (McElheran, et al., 2024). The finding of a skewed adoption of AI among larger firms also holds at the industry-level and is therefore not driven by e.g. countries' sectoral composition. Growth in AI investments is also found to be more pronounced among ex ante larger firms in the US (Babina, Fedyk, He, & Hodson, 2024).

Figure 2.2.3 **Share (%) of enterprises (with at least 10 employees) using at least one AI technology – EU firms by size class.**



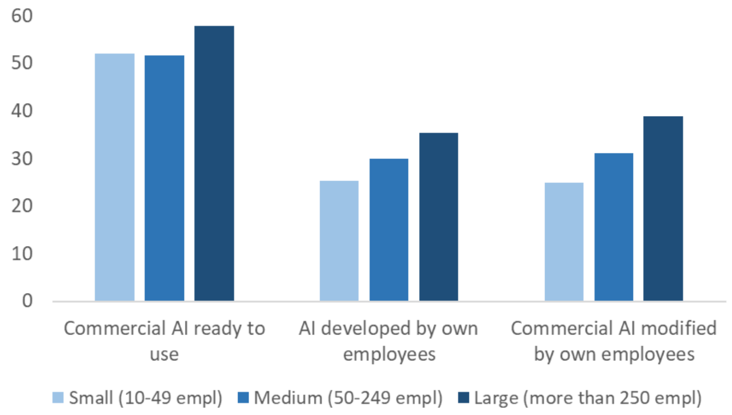

Source: Eurostat survey (2023) on ICT usage in enterprises [isoc_e].

Other firm characteristics beyond size may play a role in the firm's decision or ability to adopt AI.

- More digitalised firms (i.e. using a higher number of digital technologies and with a higher presence of ICT specialists) are more likely to use AI, which points to the existence of complementarities between AI adoption and a firm's digital assets and intangibles, notably ICT skills and firm-level digital capabilities (Calvino & Fontanelli, 2023a), (Babina, Fedyk, He, & Hodson, 2024).
- "Organisational intangibles" among startups, notably a reliance on intellectual property (IP) and process innovation and the presence of venture capital funding, are associated with AI adoption (Calvino & Fontanelli, 2023a).
- Characteristics of the owner of the enterprise may also play a role: younger, more highly educated leaders positively affect AI use among start-ups (Calvino & Fontanelli, 2023a).
- AI users tend to be on average more productive ex ante, although controlling for other firm characteristics usually weakens the link between productivity and AI use (Calvino & Fontanelli, 2023a), (Babina, Fedyk, He, & Hodson, 2024).

Adoption of AI systems can take the form of off-the-shelf commercial solutions or own-developed AI systems, and the choice between them depends on factors like the company's size, digital competence, and available resources. Larger enterprises, with more resources and in-house expertise, may opt for developing their own AI solutions to address specific needs, while smaller companies might find commercial solutions a more accessible way to harness AI's potential. Eurostat's survey contains information on the type of AI technology implemented by the firm, across different size classes. Firms tend to prefer ready-to-use solutions over developing their own (Figure 2.2.4). While the share of firms relying on commercial ready-to-use AI technologies is quite consistent across different firm sizes, larger firms are relatively more likely to have their employees develop or modify AI technologies themselves.

Figure 2.2.4 **Share (%) of enterprises (with at least 10 employees) choosing each type of AI solution – EU firms by size class.**




Source: Eurostat survey (2023) on ICT usage in enterprises [isoc_e].

# 3. ECONOMIC IMPLICATIONS OF AI

## 3.1. PRODUCTIVITY

The adoption of existing AI systems can have a tangible impact on productivity already over the short term in a number of tasks and occupations.

- Embracing AI solutions can in theory enhance firm productivity and the efficiency of specific tasks, by accelerating and improving the decision-making process as well as through the automation of manual processes (European Investment Bank (EIB), 2021). In particular, predictive AI is suitable for tasks such as targeted marketing, customer service, maintenance of equipment and suggestion of services. By contrast, generative AI can prove useful for calculations, automation of routine tasks, assistance in writing, speaking and translating, identification of patterns and even simulation of scenarios (e.g. simulation of reactions to vaccines).
- Recent engineering and consultancy studies on specific uses of AI find positive results along the same lines. Thanks to AI, software engineers code twice as fast , similar to the magnitude observed in the case of writing tasks (Noy & Zhang, 2023). Additional evidence points to an increase of 14% on average in productivity in call centres (Brynjolfsson, Li, & Raymond, 2023) and around 20% for economists (Korinek, 2023a). In total, it has been estimated that around 80% of (US) jobs would have at least 10% of their tasks that could be affected by AI and that about 15% of workers' tasks could be completed faster with no compromise on the level of quality (Eloundou, Manning, Mishkin, & Rock, 2023). In the medium run, AI could also spur human capital via other channels such as better-performing health and education systems.[17]

[17] While the development of personalised medicine is well on its way, education has not fully embarked on this journey, with some exceptions. For instance, Estonia is developing infrastructure using AI to give teachers and students greater autonomy, enhancing pupils' experience. So far, this does not seem to have damaged educational outcome, as Estonia is the highest-ranked country in Europe on the Programme for International Student Assessment (Pisa) scale. This might also have the advantage of including more people in learning paths, by, for instance, making neurodiversity no longer a bottleneck to learning.

The firm-level evidence on the impact of AI so far reveals positive revenue effects while the link is weaker for what concerns productivity.[18]

- A positive association between AI adoption and revenue growth a few years after adoption is found within US firms, which could be indicative of performance gains following AI use.[19] Moreover, US firms that invest more in AI are found to experience higher growth in sales as well as employment, a finding that holds across all industries (Babina, Fedyk, He, & Hodson, 2024). The significant impact of AI on firm growth could be associated to increased product innovation (e.g. in the form of patents, trademarks or updates to product portfolios), consistent with AI lowering the costs of product development.[20]
- Yet, most studies cannot convincingly establish a causal relation from AI use to productivity. Accounting for a firm's complementary assets as control variables substantially reduces the significance of the productivity premium related to AI use (Calvino & Fontanelli, 2023a). These assets include the firm's digital capabilities, its workforce's digital skills and the digital infrastructure it has in place, and typically explain an important part of the positive link between AI and productivity as they help leverage AI more effectively. The interaction between AI and complementary assets highlights the complexity of measuring AI's impact. AI does not operate in a vacuum; its effectiveness and the value it adds to a firm depend heavily on the firm's existing assets and capabilities. Indeed, while the use of any advanced technology is associated with ca. 11% higher labour productivity among US firms, this significantly positive association does not hold for AI use specifically, but only for cloud computing, robotics and specialised software Acemoglu, et al., 2022). Nonetheless, some studies found a significant AI impact on productivity. For instance, AI is found to significantly increase firm productivity (measured as sales, controlling for all other inputs to the production function) by about 5% among a sample of German firms with at least five employees (Czarnitzki, Fernández, & Rammer, 2023).

Inference on the AI productivity potential from existing firm-level studies is subject to a number of caveats.

- Most studies that explore the link between AI use and productivity suffer from methodological or data constraints that prevent them from establishing a causal relation. In this respect, it is particularly important to control for the confounding effect of self-selection of more productive and digital firms into AI use. For the subset of firms that develop AI themselves (in contrast to buying), a positive effect of AI on productivity, not due to self-selection, is found for a sample of French firms.[21] This could imply that, in contrast to AI buyers who need more time, AI developers already possess the complementary digital assets and skills needed for the productivity-enhancing effects of AI to emerge.
- Nevertheless, the lack of evidence for the impact of AI on productivity could be due to the time needed for such an impact to materialise. Indeed, the investments in complementary assets, necessary to fully exploit the potential of AI at the firm level, are initially costly and take time to develop (Brynjolfsson, Rock, & Syverson, 2021).
- Existing studies fail to capture the productivity impact of the most recent generative AI applications, whose effects could be quite different from those of predictive AI models. Some evidence is however available on the impact of generative AI applications on workers'

[18] Similarly to other technologies, AI is also likely to be everywhere except for the productivity statistics (This concept was first described in 1987 by economist and author Robert Solow, who stated, "You can see the computer age everywhere but in the productivity statistics." It refers to the difficulty of capturing technology-driven boost in productivity in the statistics). The output of knowledge workers is difficult to measure and could, therefore, escape standard measurements of productivity. For instance, if economists write deeper and more comprehensive analysis thanks to AI, this would not be captured in productivity statistics, despite readers benefitting from a better product (Baily, Brynjolfsson, & Korinek, 2023).

[19] Controlling for a set of markers of high-growth potential, see (McElheran, et al., 2024).

[20] See (McElheran, et al., 2024). The econometric analysis in this paper does not seem suited to credibly establish a causal link, however.

[21] See (Calvino & Fontanelli, 2023b). This finding is robust to using different specifications: using labour productivity growth rates instead of levels as well as employing TFP rather than labour productivity as productivity measure. The authors demonstrate that the positive association between AI use and productivity among developers is not due to self-selection of those firms into AI use.

performance (Brynjolfsson, Li, & Raymond, 2023) and . The impact estimated is largely positive, although these findings cannot be interpreted as evidence of positive gains at the level of the overall firm.

Compared with previous IT and digital innovations, AI improvements can be wide-reaching and long-lasting.

- AI shows dynamic economies of scale that depend not only on increased hardware power, but also on learning feedback. The power of AI models grows over time thanks to continuous learning from use, wider availability of data, and more compute power, sustaining productivity gains. The power of AI tools has been estimated to double every six months. This is much faster than Moore's law (capacity of computer chips doubles every 2 years), which, alone, is claimed to explain 10 to 20% of the productivity growth observed over the period 1960-2019.[22]
- On top, AI could increase the rate of innovation, with, in turn, could have a potentially significant impact on productivity. By deploying AI, workers can also engage with creating new things at a faster pace, e.g., R&D, which, in turn, would magnify the impact of AI on productivity over time. This would be equivalent to, for instance, applications of AI whose objective is to improve AI itself (Baily, Brynjolfsson, & Korinek, 2023).

A number of AI-specific features create uncertainties on the full exploitation of potential productivity gains. First, uncertainty on the property rights underpinning AI applications may reduce incentives to innovation. Second, AI requires large complementary investments in intangible capital for its adoption. It has been shown that data capital, such as data, knowledge, and expertise, more than other forms of intangible capital, can be harder to acquire for late adopters and new entrants, as it is protected by property rights and cannot be imitated or replicated like other forms of intangible capital (e.g., software) (Corrado, Haskel, Jona-Lasinio, & Iommi, 2022). This would tend to reduce the possibility of a wide diffusion of AI applications. Third, the much larger computing power needed to run recent AI models as compared with early predictive AI applications raises an issue of compatibility of AI developments with environmental constraints. Such constraints are linked not only with AI-generated emissions and with the scarce raw materials needed for the production of chips and other hardware elements but also to the very large water requirements to cool hard disks and other equipment. Last but not least, AI has the potential to affect societies more radically than previous IT and digital innovations, not only in terms of its impact on labour demand, but more generally by raising questions on the role of human expertise, attributions of key decisions to algorithms, incentives for self-improvement for humans, etc. The risk of backlash against the wide application of AI appears therefore more serious as compared with that encountered by other IT and digital innovations (Korinek, 2023b).

According to some existing assessments, the widespread adoption of AI could drive a 7% increase in global GDP over the next 10 years.[23] Scenarios have been formulated also contingent on further breakthroughs in AI advancements (Korinek, 2023b). In particular, three scenarios have been put forward:

- Scenario I: Advances in AI increase productivity and automate some work, but also create jobs that are more productive than the ones that were replaced. This scenario is 'business as usual case', meaning that no further AI breakthrough is envisaged.
- Scenario II: AGI is reached within 20 years, meaning that all human work tasks can be performed by AGI by the end of the period, devaluing labour.
- Scenario III: Same as scenario II, but within 5 years.

[22] (Azar, 2021).

[23] See (Goldman Sachs, 2023a). This result is based on the estimation that about 2/3 of occupations will be exposed to some degree to AI and that 7% of the jobs will be completely replaced by AI. A few assumptions follow: (i) most of those that lose their job found an at-least-as-productive job over ten years and (ii) those that are complemented by AI increase their productivity drastically. The broad improvement would add 1.5 percentage points to US labour productivity — which would be about double the current rate.

Output growth is accelerating in all scenarios, but it is much faster in scenario II and III, as scarcity of labour is not a constraint once AGI is reached, which also implies a stall in wage growth.[24]

Overall, productivity developments from AI will largely depend on adoption rates going forward, further improvements in AI systems' capabilities, policy frameworks and societal attitudes. However, gains from AI might potentially be sizable and long-lasting. In light of the remarkable differences in AI adoption across countries, sectors and firm types, there is still ample room for further progress for what concerns the diffusion of AI, notably among small firms, which are those that are most severely affected by bottlenecks to adoption. Most experts agree also on a large potential for further technological improvements in AI systems.

## 3.2. LABOUR MARKETS

Like other technological innovations, AI increases the demand for the skills needed for its development and adoption. AI development, implementation and use requires digital and IT skills. Like other IT innovations, AI is also likely to be "skill biased" in this respect, i.e., to increase the relative demand for workers endowed with relevant skills. In some firms intensively using AI, there is demand for specific AI-related jobs, such as prompt engineer, metaverse architect, avatar crafter, large language model lawyers, and personal data manager. In the short term, the main net employment impact of AI adoption might be positive, as the most immediate need is the creation of a sufficient skill endowment. Some recent studies confirm this channel (Albanesi, Da Silva, Jimeno, Lamo, & Wabitsch, 2023), with one study finding that a majority UK firms using AI and other automated technology reported a positive net employment effect (Hayton, Rohenkohl, Pissarides, & Liu, 2023).

However, in the short-to-medium run, AI might also replace routine-clerical jobs. Most AI systems are able to perform many clerical tasks more efficiently than most clerical workers.[25] In this respect, AI will likely contribute to the phenomenon of "labour market polarisation", as it might erode the relative demand for workers with medium-paying jobs.

Unlike other previous innovations, over the medium-to-long term AI has also the potential to increasingly replace high-skilled labour performing non-routine tasks. In particular, generative AI can replace tasks which have been considered 'safe' from automation until now as it can perform tasks (e.g., coding, ideation, etc..), which are performed by non-routine cognitive workers. However, such an impact may unfold gradually over time and may be delayed by policy and social preferences.

- Generative AI applications are currently operated together with human intervention to direct and judge output quality. Generative AI models are still prone to mistakes (also called "hallucinations"). However, once (if) AI output becomes accurate from the incorporation of additional information and learning, the need for human intervention will gradually diminish.
- A number of occupations will likely remain shielded, at least for some time, because of regulations, social norms or low incentives to invest in automation. This would notably be the case, for instance, for professions in the health sector, other regulated professions, the education sector, and academia. Some personal service jobs —such as hospital orderlies, nannies, and doormen— might also remain untouched because they are characterised by relatively low pay, providing little incentive for AI-based replacement and also because of demand-side preferences for humans to perform jobs in personal services where interpersonal skills are required (Brynjolfsson & Unger, 2023).

Like most labour-saving innovations, labour demand may suffer in the short-to medium run if the displacement of routine-clerical jobs outpaces AI-related job creation, but demand could recover over the longer term in light of higher aggregate income and capital accumulation. The fact that many AI applications would replace the execution of given tasks performed by labour would imply a reduction in

[24] Estimates reported in (Korinek, 2023b) (i) under scenario I, output doubles within 25 years, (ii) under scenario II, output quadruples within 20 years and (iii) under scenario III, output quadruples within 10 years.

[25] According to a recent ILO study, 58% of clerical tasks face a medium risk of automation, while 24% are at high risk (Gmyrek, Berg, & Bescond, 2023).

labour demand for workers performing these types of tasks.[26] However, the widespread use of AI will generate demand for new tasks and productivity growth will be associated with higher income, savings and investment, and therefore increased demand for goods and services, which will in turn support labour demand (e.g., in analogy with the rise of employment in services following the introduction of labour-saving techniques in agriculture and manufacturing).[27] Hence, as in previous major innovations that have increased labour productivity, the economy-wide effects of productivity improvements if sufficiently strong and widely distributed would tend to offset over time the temporary potential reduction in labour demand caused by the introduction of labour-saving techniques. However, the implications for the relative demand for labour and the aggregate wage share remain uncertain.

All in all, the effects of AI on income distribution could be quite different compared with those of previous IT innovations, but the exact way in which such effects will unfold is surrounded by substantial uncertainty.

- Like for previous innovations, there would be an erosion of the relative and possibly absolute earnings for workers with routine occupations.
- Lower-skilled labour might gain in relative terms. In addition to trends linked to structural shortages, such as possible absolute gains for workers with specialised manual skills, the productivity of some workers would be boosted without being replaced by AI systems.[28] AI could also ease the labour market inclusion of vulnerable workers by enabling innovations that enhance the productivity of workers with disabilities. Furthermore, AI can support workers' skills (e.g., via production of text and/or code) and adding in-demand tasks to job profiles (e.g., diagnostics to nurse practitioners).[29]
- The extent to which AI models will replace high-skilled occupations and expertise - thus putting downward pressure on their relative earnings - as well as their timing and modalities, will depend on a complex interplay of technological, economic, and political factors which would be partly country-specific.

# 4. POLICY APPROACHES TO DEAL WITH AI

## 4.1. REMOVING BOTTLENECKS TO ADOPTION

Surveys indicate that EU businesses see the potential of AI, but face barriers to adoption. Eurostat's 2023 survey on ICT usage in enterprises provides country-level information on firms' reasons for non-adoption. For the EU as a whole, the lack of relevant expertise (almost 70%) stands out as the most important barrier to adopt AI (Figure 4.1.1). Further barriers are linked to system incompatibility, data availability, high costs and regulatory aspects. The importance attached to the different types of barriers varies quite remarkably across EU countries, which confirms that existing policy and regulatory settings play a role in affecting firms' perceptions. Nonetheless, the overall prevalence of high upfront costs and lack of skills as perceived barriers to AI adoption is confirmed also in a recent OECD survey on AI use among employers and workers (Lane, Williams, & Broecke, 2023). That survey also finds that regulatory aspects constitute quite a significant barrier across most countries covered. Some evidence focusing on the public sector points also to the relevance of socio-cultural factors, including trust, for the adoption of emerging technology (Millard, Manzoni, & Schade, 2023).

[26] In a model with labour performing tasks replaceable by capital it has been shown that displacement effects would imply a falling labour share and possibly lower real wages despite higher labour productivity in light of the direct labour demand destruction associated with displacement. See (Acemoglu & Restrepo, 2018).

[27] Such a result holds generally under the assumption of constant returns to scale, perfect competition, mobile capital, see, e.g., (Caselli & Manning, 2019), and the task model developed in (Acemoglu & Restrepo, 2018).

[28] (Brynjolfsson, Li, & Raymond, 2023) on the use of AI models in call centres found a 14% productivity increase on average, with the greatest impact on novice and lower-skilled workers, and minimal impact on experienced and higher-skilled workers.

[29] A survey on the use of AI in firms finds that employers were optimistic that AI would help workers with disabilities (Lane, Williams, & Broecke, 2023).

Figure 4.1.1 **Share (%) of enterprises (with at least 10 employees), which ever considered to use AI, that face this barrier to adopt AI – EU firms**


Source: Eurostat survey (2023) on ICT usage in enterprises [isoc_e].

Policy intervention may be justified to remove barriers to AI adoption since the net gains from AI development and adoption for individuals are lower than the overall net gains for society.

- The development and use of AI, associated with learning effects, generate relevant knowledge spillovers and positive externalities, leading to aggregate gains that increase as a larger share of firms engage in AI-related innovations and adopt AI technologies.
- Moreover, learning effects contribute to magnify and perpetuate advantage gains for early AI innovators and early adopters of AI solutions via self-reinforcing loops. This means that there are adoption barriers for small firms and newcomers, which may imply sub-optimal diffusion.

Policies to prompt AI innovations and diffusion need to act simultaneously on multiple factors. The following aspects appear of the highest relevance for reducing bottlenecks, thus enhancing adoption capabilities, especially of small firms facing financial constraints and lacking in-house digital expertise (Berlingieri, Calligaris, Criscuolo, & Verlhac, 2020): (i) easing access to key infrastructure such as compute power and data and removing financial constraints hampering intangible investments in AI capabilities for small firms; (ii) developing the required skills needed for AI development and adoption and making them more accessible to firms including by promoting knowledge sharing[30]; (iii) promoting the adoption of digital innovations; (iv) addressing the remaining fragmentation of the EU digital market including with a view of supporting the creation of large, integrated data sets needed to train AI models.[31]

In parallel, policies have also been focusing on enhancing AI development. In the Coordinated Plan on AI of 2018 and its subsequent 2021 review (which was part of the 2021 AI package)[32], for instance, the European Commission recommended that Member States adopt national AI strategies with policy actions and investments to support the development and uptake of AI. Most Member States have published

[30] According to a study by the Center for Data Innovation, the EU can rely on a large pool of AI talent, as indicated by a relatively high number of AI researchers as a share of the total population, in line with the US and far ahead of China (Castro, McLaughlin, & Chivot, 2019). The quality of AI researchers (e.g. publishing at leading AI conferences) seems to be somewhat lower than that in the US, however.

[31] While the availability of data for AI purposes is not straightforward to measure, the EU seems to be disadvantaged when considering proxy indicators, such as the share of the population engaging in digital activities that lead to the creation of large data sets (e.g. broadband subscriptions and mobile payments) (European Investment Bank (EIB), 2021).

[32] COM/2021/205 final COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Fostering a European approach to Artificial Intelligence EUR-Lex - 52021DC0205 - EN - EUR-Lex (europa.eu).

national AI strategies. In addition, Finland, Germany, France and Cyprus have already published updated editions of their initial AI strategies (Jorge Ricart, Van Roy, Rossetti, & Tangi, 2022). Similarly, the Digital Decade policy programme includes a target of 75% of EU companies using Cloud, AI, or Big Data by 2030.[33] More recently, the European Commission launched an AI innovation package to support AI startups and SMEs via a broad range of measures, including a proposal to provide privileged access to supercomputers to AI startups.[34]

## 4.2. REGULATING AI: TRANSPARENCY, INTELLECTUAL PROPERTY, PRIVACY, HUMAN RIGHTS, SECURITY

As AI develops and spreads, regulatory frameworks need to be updated. Regulatory gaps appear relevant especially for what concerns transparency, accountability, non-discrimination, unethical practices of control, as well as data collection and its usage.

The EU has proposed the first ever legal framework on AI in April 2021. On December 2023, the Council presidency and the European Parliament's negotiators reached a provisional agreement on the Artificial Intelligence (AI) Act. The AI Act was published in the EU's Official Journal on 12 July 2024 and will gradually enter into force as of August 2024 making the EU the first major political organisation to set binding rules for AI, i.e., to ensure AI is trustworthy, safe and respects EU fundamental rights, while supporting innovation.[35] The Act sets comprehensive rules for AIand addresses risks of specific uses of AI, categorising them into 4 different levels: (i) unacceptable risk (implying banning of AI systems); (ii) high risk (obligations to be fulfilled); (iii) limited risk (transparency obligations to be fulfilled); (iv) minimal risk (see Box 4.2.1). The AI Act builds upon the Ethics Guidelines for Trustworthy Artificial Intelligence prepared by the High-Level Expert Group on Artificial Intelligence in 2019 as part of the EU AI Strategy.[36]

[33] Decision 2022/2481. Decision (EU) 2022/2481 of the European Parliament and of the Council of 14 December 2022 establishing the Digital Decade Policy Programme 2030 Decision - 2022/2481 - EN - EUR-Lex (europa.eu).

[34] COM/2024/28 final COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on boosting startups and innovation in trustworthy artificial intelligence EUR-Lex - 52024DC0028 - EN - EUR-Lex (europa.eu).

[35] Regulation 2024/1689. REGULATION (EU) 2024/1689 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act) Regulation - EU - 2024/1689 - EN - EUR-Lex (europa.eu).

[36] The Ethics Guidelines for Trustworthy Artificial Intelligence (AI) is a document prepared by the High-Level Expert Group on Artificial Intelligence (AI HLEG). This independent expert group was set up by the European Commission in June 2018, as part of the COM/2018/237 final COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Artificial Intelligence for Europe EUR-Lex - 52018DC0237 - EN - EUR-Lex (europa.eu). The requirements for trustworthy AI identified by the group are:

- Human agency and oversight. Including fundamental rights, human agency and human oversight,
- Technical robustness and safety. Including resilience to attack and security, fall back plan and general safety, accuracy, reliability and reproducibility,
- Privacy and data governance. Including respect for privacy, quality and integrity of data, and access to data,
- Transparency. Including traceability, explainability and communication,
- Diversity, non-discrimination and fairness Including the avoidance of unfair bias, accessibility and universal design, and stakeholder participation,
- Societal and environmental wellbeing. Including sustainability and environmental friendliness, social impact, society and democracy,
- Accountability. Including auditability, minimisation and reporting of negative impact, trade-offs, and redress.

Box 4.2.1 **KEY ELEMENTS OF THE AI ACT**

- Banned applications: a number of applications will be banned, such as biometric categorisation systems that use sensitive characteristics (e.g. political, religious, philosophical beliefs, sexual orientation, race); untargeted scraping of facial images from the internet or CCTV footage to create facial recognition databases; emotion recognition in the workplace and educational institutions; social scoring based on social behaviour or personal characteristics; AI systems that manipulate human behaviour to circumvent their free will; AI used to exploit the vulnerabilities of people (due to their age, disability, social or economic situation). Some exceptions apply to the use of real time biometric identification systems in limited cases linked, for instance, to targeted searches of victims or prevention of terrorist threats.
- Obligations for high-risk systems: high-risk AI are systems that have a significant potential harm to health, safety, fundamental rights, environment, democracy - this includes systems that influence voting behaviour- and the rule of law. These systems require a mandatory fundamental rights impact assessment if deployed by public authorities.
- Guardrails for general-purpose AI (GPAI): These systems have a wide range of applications and are subject to transparency obligations, which include, for instance, technical documentation, complying with EU copyright law and disseminating detailed summaries about the content used for training. They might also involve conducting model evaluations, assessing and mitigating systemic risks, reporting to the Commission on serious incidents, ensuring cybersecurity and reporting on their energy efficiency. For the largest systems, adversarial testing will be mandatory. Additionally, artificial or manipulated images, audio or video content ("deepfakes") need to be clearly labelled as such.
- Measures to support innovation and SMEs: so-called regulatory sandboxes and real-world-testing will be established by national authorities and made accessible to SMEs and start-ups to develop and train innovative AI.
- Governance: several governing bodies are set up:

  1. An AI Office within the Commission to enforce the common rules on General Purpose AI across the EU
  2. A scientific panel of independent experts to support the enforcement activities
  3. An AI Board with member states' representatives to advise and assist the Commission and member states on consistent and effective application of the AI Act
  4. An advisory forum for stakeholders to provide technical expertise to the AI Board and the Commission

- Fines: The maximum fines for infringements are set as a percentage of the company's global annual turnover in the previous financial year or a predetermined amount, whichever is higher. SMEs and start-ups are subject to proportional administrative fines.

Differences in regulatory approaches across major world areas require global regulatory cooperation. The EU has followed an approach with a stronger role for binding regulations reflected in the AI Act. In contrast, the United States as well as other countries including the UK has so far introduced relatively little regulatory requirements and rather focused on guidelines and principles. China positions somewhat in middle as it provided guidance on areas and products that AI companies should not invest on, while it is drafting a comprehensive AI law. This difference in regulatory approaches has implications for private sector incentives and require global cooperation to ensure enforcement and a level-playing field. To this end, the Organisation for Economic Co-operation and Development (OECD) has identified AI standards and principles; the G7, and G20, have adopted broad principles and new initiatives, such as the G7's recent 'Hiroshima AI process' to regulate generative AI. In parallel, the

United Nations (UN) have launched a new AI high-level advisory body, and the EU and the US are cooperating on voluntary codes of conducts.[37]

AI's potential impact on economic security is currently under scrutiny by the EU. The assessments of a number of technologies and their value chains, which include AI, are being carried out to identify potential vulnerabilities and their impact on the EU's economic security.[38] These concerns are namely about resilience of supply chains, including energy security; physical and cyber-security of critical infrastructure; technology security and leakage; weaponisation of economic dependencies and economic coercion, and the degree of likelihood that these risks materialise. For example, a malfunction in AI could lead to a loss of competitive advantage or the undermining of national security. AI has also a wide range of dual-use applications and a number of AI applications seem to have been tested and deployed in ongoing conflicts, alerting governments worldwide about the potential role of AI in shaping conflicts.

Concerns have also been expressed regarding the impact of AI applications on the regularity of political processes (Bremmer & Suleyman, 2023). In particular, AI might undermine electoral outcomes via channels such as the production of disinformation during political campaigns. More generally, it has been argued that technology and autocratic regimes may be mutually reinforcing as AI offers control options which can be fully exploited when data collection is centralised (Beraja, Kao, Yang, & Yuchtman, 2023). However, AI could also be democracy-enhancing as, for instance, it provides tools to conduct and analyse large-scale consultations (Landemore, 2023).

Uncertainty on property rights underpinning the output of AI applications would have potentially wide-ranging implications. Legal uncertainty on the returns on AI output would depress the incentives to carry out investments to develop AI. More generally, the weakening of property right protection on content used in AI applications could reduce incentives to generate such content in the first place with negative implications for innovative activity.[39]

## 4.3. ISSUES FOR COMPETITION POLICY

AI may lead to market structure concentration. AI might induce winner-take-most dynamics by skewing the distribution of profits and market shares in favour of large businesses. Large corporations are more likely to adopt, deploy and even develop AI (Goldman Sachs, 2023b). Indeed, given the role of access to data for AI systems, they are structurally in a better position, including because they are more likely to have large datasets in-house and because of better access to cloud infrastructure. The cost of deploying AI is also very high and particularly so for SMEs, especially for data processing, storage, and integration in the software systems. As such, AI investments can lead to increased industry concentration by reinforcing winner-take-most dynamics. Indeed, positive feedback loops between AI use and firm size are likely: AI investments concentrate among larger firms as they have the financial means to develop/buy AI, and as they invest in AI, these firms gain sales, employment, and market share (Babina, Fedyk, He, & Hodson, 2024).

A growing concentration of data capital in the hands of few firms would also have negative implications for the diffusion of AI applications and for the growth effects of AI in general. Policies may help addressing such concerns and foster diffusion by ensuring broad access to data (e.g. through data sharing initiatives, promotion of access to copyrighted data for AI training). Besides access to data, policies may also favour access to cloud infrastructure and computing power, as well as AI engineering

[37] Some efforts have also been made to build a shared governance vision of AI. Among those, The UK held an AI safety summit in early November which saw the participation of the US, the EU, China, scientists and executives of leading AI companies.

[38] C/2023/6689 OJ L, 2023/2113 Commission Recommendation (EU) 2023/2113 of 3 October 2023 on critical technology areas for the EU's economic security for further risk assessment with Member States EUR-Lex - 32023H2113 - EN - EUR-Lex (europa.eu).

[39] However, some economic arguments would push in favour of reducing copyright protection for both AI inputs and outptuts. On AI inputs, AI-driven welfare gains might suffer from the (over)protection of private interests of certain groups that might decide against authorising the use of media content for training of (generative) AI models. On output, it is argued that the use of AI leads to an almost null incentive for piracy, thus making copyright on output not necessary (Martens, 2024).

talent.

AI algorithms may also have additional implications for competition policy by affecting firms' behaviour. When navigating the range of available products, consumers are increasingly relying on AI-powered recommender systems instead of individual search. These systems predict users' preferences and provide personalised recommendations by collecting information on users' valuations in the past as well as valuations by other users, as is common on platforms such as Netflix, Amazon and YouTube. The spread of algorithmic recommendations has raised concerns about their potential to increase sellers' market power at the expense of consumers. Also, there may be a "feedback loop" issue as the algorithms are (re)trained with data they helped generate themselves, leading to "rich-get-richer" dynamics.40 Moreover, studies have shown that AI pricing algorithms may lead to implicit collusion.[41]

## 4.4. DEALING WITH THE IMPACT ON LABOUR MARKETS AND DISTRIBUTION

The first goal of policy to address the labour market implications of AI would be skill development, support for displaced workers, and ensuring fair working conditions.

- To face AI-driven reallocations needs, policies should target the development of the right skillset. While digital skills and digital literacy are a prerequisite for most jobs in AI or jobs complemented by AI, vacancy data suggest that other skills are also in demand, including leadership, innovation, and problem-solving skills Borgonovi, et al., 2023). In addition, labour shortages are widespread across occupations and set to persist in a number of EU countries in light of ageing and shrinking working age population. This has mainly implications for education curricula, the provision of high-quality vocational education and training, the design of training for upskilling and re-skilling the workforce and for activation. Policy should also be geared towards removing bottlenecks to the supply of labour in the context of labour shortages, including by exploiting AI's potential to activate groups that face barriers to work, such as people with disabilities.
- Adequate safety nets and active labour market policies need to be put in place for workers performing routine tasks displaced by AI applications and increased automation.[42] Policy should facilitate labour reallocation and measures to up-skill and re-skill the labour force in line with the Commission Recommendation for Effective Active Support to Employment.[43] Measures to beef up training in the context of active labour market policies and to strengthen public employment services would help easing joblessness caused by AI-related displacements. Policy should also address the adequacy of safety nets and social security entitlements. Social safety nets need to be adapted to cater for changes in business practices (including the "platform economy").[44]
- Risks of worsening job quality can be addressed via regulation and the promotion of best practices among social partners. Concerns have been raised especially regarding the possible

[40] A study on the implications of algorithmic recommendations on product market competition shows that recommender systems lead to higher market concentration and prices compared to when consumers rely on individual search only. However, they also increase consumer surplus as a result of better user-item matching and lower search costs. See (Calvano, Calzolari, Denicolo, & Pastorello, 2024).

[41] It has been shown that AI algorithms learn to collude: they punish deviating strategies, but also learn to forgive and reward collusive actions, leading to prices above the competitive level. Importantly, the algorithms were not instructed or designed to play the collusive strategy, but instead decided to do so without communicating. As such, this form of tacit collusion would, in theory, be lawful. See (Calvano, Calzolari, Denicolo, & Pastorello, 2020).

[42] These policies would also need to account for the potential growing gap between productivity and compensation, a trend observed with previous technological advancements. If the gains from increased productivity due to AI do not reach society, social tension and decreased consumer spending power could follow, thus affecting overall economic growth.

[43] C(2021) 1372 final COMMISSION RECOMMENDATION of 4.3.2021on an effective active support to employment following the COVID-19 crisis (EASE) EUR-Lex - 32021H0402 - EN - EUR-Lex (europa.eu).

[44] In line with the 2019/C 387/01 Council Recommendation of 8 November 2019 on access to social protection for workers and the self-employed EUR-Lex - 32019H1115(01) - EN - EUR-Lex (europa.eu).

use of AI algorithms in such a way that reduces workers' autonomy, increases control and surveillance and reduces transparency of human resource decisions. Despite existing surveys not always confirming a reduction in the perceived job quality by workers after introducing AI solutions[45], there is a widespread concern that further use of AI applications in managing human resources would go hand in hand with increased intensity of routine work.[46] Regulatory initiatives have been taken recently especially to deal with the implications of algorithmic management on transparency of human resource decisions and on job quality in the case of "platform workers", with the Commission having presented a Directive on Platform Work.[47]

Another aspect to be monitored would be that of managing the social transformations associated with the worsening job and earning prospects for high-skilled workers.

- Policies will likely be geared in the direction of making such transformations sufficiently gradual to be acceptable according to social and cultural norms. Moreover, there could be a growing awareness of governments about the societal implications of AI innovations, with the implication of a stronger involvement in steering AI developments to discourage the most disruptive applications (Acemoglu & Restrepo, 2020). As social norms differ across countries, differences in regulatory and legal aspects can be observed, implying that different regions and countries may follow distinct paths.
- Regulatory aspects affecting the employment and earnings prospects of skilled workers will extend beyond regulated professions, employment protection or public employment (such as in education, university, and public administration) to more broadly include issues related to intellectual property rights (such as who owns the output of AI systems and who gets paid for it), the compliance of AI solutions with the broader regulatory framework (including health and safety), and the ability of AI solutions to perform tasks involving judgement with significant social and legal implications (such as driving, grading students, diagnosing health conditions, assessing compliance with public regulations and standards, and deciding on court cases).
- The implications of falling demand for high skills would, in turn, raise the issue of whether and how to maintain an adequate supply of highly educated labour despite falling relative earnings.

Policy makers are also faced with the challenge of reassessing how tax systems influence incentives for AI adoption, while preparing for the impact of AI on tax systems and administrations.

- Tax collection and compliance can be enhanced by AI tools. The first evaluations of technology adoption by tax administrations show positive results over a large array of outcomes, including higher tax revenues, but this comes with some caveats. First, the realisation of revenue gains depends on accompanying factors, such as administrative reforms, as well as the availability of adequate digital connectivity and capable tax administration staff (Nose & Mengistu, 2023). Second, algorithms used in tax administrations have shown to be also prone to bias, which can have serious implications for society, for instance in the form of false allegations of tax fraud directed towards vulnerable groups of society.
- Concerns have been expressed about long-run revenue losses in case of falling labour income due to AI. It has been argued that the relatively high effective taxation on labour as compared with other tax bases provides an incentive to firms to invest in algorithms to automate work. In

[45] Existing surveys however do not always confirm a perceived reduction in job quality by workers after the introduction of AI solutions (Hayton, Rohenkohl, Pissarides, & Liu, 2023).

[46] In the healthcare sector, AI applications have also been linked with a risk of cognitive exhaustion, as humans are left with the most brain-intensive tasks. (Benhamou, 2020).

[47] On 11 March 2024, EU employment and social affairs ministers confirmed the provisional agreement reached on 8 February 2024 between the Council's presidency and the European Parliament's negotiators on the platform work directive. The European Parliament gave its approval of the provisional agreement on 24 April 2024. This EU legal act aims to improve working conditions and regulate the use of algorithms by digital labour platforms.

the economic debate it has therefore been suggested that tax structures should equalise marginal tax rates for hiring (and training) labour and for investing in equipment and software (Acemoglu, Manera, & Restrepo, 2020). However, such a change in tax schemes comes with a risk of delaying technology adoption, which is likely to be costly for society in the long run, as it might manifest in foregone growth.[48]

Finally, AI may also have implications for financial stability, regulation and monetary policy pass-through.

- With the financial sector at the forefront of AI adoption, issues will arise regarding systemic implications. For instance, on top of risks of biased algorithms, AI can increase systemic risk by amplifying potentially destabilising negative feedback loops. For instance, during crises, individual actors might end up following the same (suboptimal) pattern suggested by the algorithm which aims at profit-making rather than preserving the stability of the financial system (Danielsson & Uthemann, 2024).
- At the same time, AI's potential to promptly identify anomalies could also support the resilience of the financial system if integrated in precautionary measures.
- More 'digital' financial systems might make monetary policy more effective. The introduction of technologies might increase access and competition in the market, meaning that banks' market power diminishes. In turn, loan and deposit rates might follow policy rates more closely (Dedola, et al., 2023).
- There are also concerns regarding the possible long-term implications for financial stability resulting from a major decrease in labour income. Joblessness and reduced wage income would imply defaults on mortgages and banks' balance sheet distress, similar to the effects seen during mechanisation of agriculture in the 1920s and 1930s, which affected around 20% of the US population.[49]

# 5. CONCLUSION

This paper summarises main opportunities and challenges linked with the spreading of AI and discusses policy implications from an EU perspective.

To clarify the main features of AI as a technological phenomenon, this paper introduces key definitions and distinguishes between more recent generative AI models, which generate original content, and predictive AI models, which have been in use since the first half of the 2010s. The rapid development of AI capabilities has been driven by research breakthroughs and increasing data availability and computational power.

A number of forward-looking assessments suggest that AI could have a ground-breaking impact on productivity and economic growth. However, the realisation of these benefits depends on the rate of adoption of AI systems and improvements in their capabilities. Moreover, the potential benefits of AI could be hampered or nullified by various risks associated with its development and deployment. Policymakers are thus tasked with the challenge of keeping pace with AI advancements to maximise its benefits while minimising its risks.

Despite its potential, AI diffusion and adoption in the European Union (EU) remain limited and concentrated in a few sectors and mainly large firms. This may reflect the initial stage of AI diffusion, which could be followed by a fast-spreading adoption in the coming years in analogy with what happened with many ICT and digital innovations in previous decades. The paper highlights that, despite

[48] While the debate is also shaped by societal preferences, some studies argue in favour of taxes with decreasing magnitudes the more technology adoption deepens (Costinot & Werning, 2023) or to explore other options, such as taxing excess profit of firms with market power in the automated economy (Berg, et al., 2021).

[49] Korinek, A., (2023) Presentation at the IMF/WB Spring Meetings on Generative AI: Four Messages to Economic Policymakers.

considerable consensus on potential long-term productivity enhancements linked to AI, the empirical evidence available thus on micro data so far does not show yet substantial productivitiy gains. The limitations of existing studies lie in their focus on specific tasks or professions, which may only capture a portion of the benefits associated with AI. The continuous advancements in AI make its evaluation a moving target, and past estimates may not accurately reflect future prospects when it comes to the impact of AI on productivity.

The effect of AI on labor markets will unravel in phases and will depend on how a number of different channels play out. In the short run, AI's influence on labor markets is likely to resemble that of other digital innovations, but its impact may diverge over the medium to long term. In the short to medium term, AI is likely to complement workers rather than replacing them, but it could reduce the demand for workers in specific roles. Skilled labor may benefit, while workers engaged in routine tasks may face substitution. Over the medium to long term, however, generative AI, in contrast to previous digital innovations, could potentially replace even high-skilled labor engaged in non-routine tasks, impacting their employment and income prospects, although the extent to which this will happen as well as timing and modalities will be largely shaped by country-specific legislation and social norms. Finally, the overall productivity and income growth resulting from AI could stimulate demand in the long run, ultimately benefiting employment across sectors not directly affected by AI.

This paper identifies several questions for policymakers. The first question is how to remove existing barriers to the adoption and deployment of AI. To this purpose, policies targeting AI advancements and widespread implementation should address multiple aspects, including (i) facilitating access to essential infrastructure, such as computational resources and data, and alleviating financial barriers impeding small firms' investments in AI capabilities; (ii) developing and enhancing accessibility of necessary skills required for AI development and integration by promoting knowledge sharing; (iii) encouraging the adoption of digital innovations; and (iv) mitigating the remaining fragmentation within the EU digital market to support the creation of extensive, integrated data sets necessary for training AI models.

Second, there are regulatory gaps relating to AI that need to be filled, notably for what concerns transparency, accountability, non-discrimination, unethical practices of control, as well as data collection and its usage and broader implications for political processes and economic security. The EU AI Act addresses some of these gaps through a risk-based approach, ensuring that AI is trustworthy, safe, and respects EU fundamental rights while supporting innovation. However, there are differences in regulatory approaches across major world areas, which have implications for private sector incentives. This requires sustained global cooperation, which is underway.

Third, AI's impact on industrial structure and firms' behavior may lead to market structure concentration. AI might induce winner-take-most dynamics by skewing the distribution of profits and market shares in favor of large businesses. These dynamics have implications for competition policy and regulatory frameworks, as well as policies aimed at easing access to data (e.g., through data sharing initiatives) and computational resources.

Finally, there will be potentially wide-ranging implications of AI, notably for the distribution of income. To counteract potential income drops for (some) workers, policies should focus on skill development, including both digital skills and leadership, innovation, and problem-solving abilities, while facilitating labor reallocation and up- and re-skilling. In some countries, dealing with the implications for displaced workers may also require an adaptation of social safety nets. Income distribution may also be affected by copyright laws and their enforcement. The paper also provides an overview of the challenges that may arise for taxation, and financial stability, highlighting the need to keep on monitoring the developments in these areas in order to effectively and responsibly steer incentives while managing risks.

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