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The socio-economic and labour impacts of technological change

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The socio-economic and labour impacts of technological change

The economy, labor, and society have undergone profound changes driven by major technological disruptions that have generated new paradigms and paved the way for successive industrial revolutions. We are currently immersed in the Fourth Industrial Revolution, characterized by fully consolidated technological advances such as hyperconnectivity, the widespread adoption of the Internet of Things, the application of artificial intelligence systems, and advanced big data analytics.

The great challenge in relation to technological transformation that societies are facing is to ensure that this process, mainly digitalization, and the related developments and innovations such as artificial intelligence, are oriented toward human, social, and environmental progress.

In this special report, the Economic and Social Council of Spain seeks to identify the opportunities and challenges posed by technological change from a socioeconomic and labor perspective. It does so under the premise that its effects and impacts are not predetermined but instead depend on how they are addressed by the various actors involved, as well as on the implementation of appropriate regulatory frameworks and public policies.

Featured topic of the Report on the Socio-Economic and Employment Situation in Spain, 2024

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ECONOMIC IMPACTS OF TECHNOLOGICAL CHANGE

The economy, work and society have been profoundly changed by major technological disruptions that have generated new paradigms, paving the way for different Industrial Revolutions. We are currently immersed in the fourth Industrial Revolution, consisting of fully consolidated technological advances such as hyperconnectivity, the high penetration of the Internet of Things, the application of Artificial Intelligence systems and advanced Big Data analysis.

Over the last ten years, the Economic and Social Council (ESC) has been reflecting on the economic, work-related and social impacts of this fourth Industrial Revolution[1]. However, the breakthrough of generative Artificial Intelligence (AI), whose milestone was the launch of ChatGPT in November 2022, and its use in the field of creative skills, make it worth reflecting once again on technological change as a potential tool for generating growth pattern leading to stable, sustainable and inclusive development in the medium term.

The great challenge facing societies with regard to technological transformation is to ensure that this transformation, especially digitalisation, and associated developments and innovations such as AI are geared towards human, social and environmental progress. And while it is true that these new developments have an unprecedented potential to bring about fairer, more democratic, more efficient, more prosperous and environmentally friendly societies, this same potential may also lead to a strong concentration of market power, as well as political/geopolitical and economic power, calling into question and undermining their capacity for transformation.

The EU points out[2] that AI can generate diverse economic, environmental and social benefits for all economic sectors and social activities, providing competitive advantages for businesses, and support "socially and environmentally beneficial outcomes, for example in healthcare, agriculture, food safety, education and training, media, sports, culture, infrastructure management, energy, transport and logistics, public services, security, justice, resource and energy efficiency, environmental monitoring, the conservation and restoration of biodiversity and ecosystems and climate

1 It is worth highlighting Report 01/21 on *The Digitalisation of the Economy,* of 24 February 2021, Report 03/2018 on *The Future of Work, of* 30 May 2018, and Report 03/2017 on *The Digitalisation of the Economy*, of 25 October 2017.

2 Regulation (EU) 2024/1689 of 13 June 2024. Artificial Intelligence Regulation.

change mitigation and adaptation." [3] However, it also notes that AI can "AI may generate risks and cause harm to public interests and fundamental rights (...). Such harm might be material or immaterial, including physical, psychological, societal or economic harm".

With regard to this featured topic, the Economic and Social Council of Spain seeks to identify the opportunities and challenges posed by technological change from a socio-economic and labour perspective; and it does so under the premise that its effects and impacts are not pre-determined, but depend on how they are addressed by the different stakeholders involved, as well as on the implementation of appropriate regulatory frameworks and public policies.

1. Technological change and the fourth Industrial Revolution. Conceptual framework

The concept of technological change refers to the set of developments, transformations and disruptions driven by technological innovations that modify aspects of economic activity, labour markets and society. Technological change is the dynamic result of innovation that is triggered within a conducive context. In other words, empirically tested prior knowledge (inventions) becomes innovation when that which is technologically possibly becomes economically profitable and socially acceptable[4], i.e. when there is a convergence of technology, economics and the socio-institutional context. By improving processes, creating new business models and transforming social and economic structures, technological change becomes the main driver of societal transformation.

To employ the terminology of Pérez, C. (2010), throughout recent history, radical innovations[5] have given rise to different Industrial Revolutions that have led to quantum leaps[6] in productivity and transformed societies, and we are currently immersed in the so-called fourth Industrial Revolution or Industry 4.0 (Figure 1).

3 As stated in the International Standard ISO/IEC 22989, *Information technology – Artificial intelligence – Concepts and terminology*, there are many areas of AI technology that are evolving rapidly and are closely linked to each other, making it difficult to list all the technical fields where it is applicable. To this may be added the fact that AI is highly interdisciplinary, bringing together computer science, data science and mathematics with natural sciences, humanities, social sciences and others.

4 Pérez C. (2010): "Technological revolutions and techno-economic paradigms" Cambridge Journal of Economics, vol. 34, nº1, pp. 185-202.

5 Following the terminology of Pérez C. (2010), *op.cit*.

6 A quantum leap is a term that hails from quantum physics and refers to the sudden and unexpected change of a system from one state to another, without passing through intermediate states. Outside the scientific field, the expression "quantum leap" is used in a metaphorical sense to refer to a radical and significant advance or change in any area, such as technology, knowledge, or even in the evolution of an idea or society. Within this context, it refers to an improvement or transformation that occurs rapidly and on a much larger scale than previous changes.

FIGURE 1. INDUSTRIAL REVOLUTIONS

	Periods	Technologies and capabilities
First	1784 to the mid-19th century	The steam engine and the mechanization of production
Second	Late 19th century to the 1970s	Electrification of mass production based on the division of labor (assembly lines)
Third	1970s to the present	Electronics and ICT (computing and digital technologies). Automation of complex tasks
Fourth	Today	Artificial intelligence, massive interconnection of physical and digital systems. Internet of Things, decentralized information and control networks

Source: Based on the European Parliamentary Research Service, Industry 4.0 Digitalisation for productivity and growth, September 2015.

The fourth Industrial Revolution is defined[7] as a technological transformation that is blurring the lines between the physical, digital, and biological spheres. This revolution is characterised by interconnected exponential advances in key technologies such as Artificial Intelligence and Machine Learning, robotics, the Internet of Things, biotechnology and genetics, nanotechnology, 3D printing, blockchain and communication and connectivity technologies.

Around it, a series of disruptive technologies have emerged, with a tremendous potential to influence societies and economies. Since 2011, these technologies have been identified annually by the World Economic Forum in its reports on the "*Top 10 Emerging Technologies*". Many of the "*Top*" technologies identified in these reports have since been consolidated, effectively confirming their potential. For example, the following technologies were identified for 2024[8]: AI for scientific discoveries, privacy-enhancing technologies, reconfigurable smart surfaces, high-altitude platform stations: integrated sensing and communication, immersive technology for the built world, electrocaloric technology, carbon-capturing microbes, alternative livestock feeds or genomics for transplants. Two ideas emerge from this list of disruptive technologies: on one hand, the multi-sectoral nature of the fourth Industrial Revolution, which integrates elements from multiple fields such as health, connectivity, energy, sustainability, among others, and, on the other hand, the innovative nature of these technologies, many of which are at the forefront of knowledge in respective disciplines.

7 Schwab K. (2016): *The Fourth Industrial Revolution.*

8 *Centre for the Fourth Industrial Revolution, Top 10 Emerging Technologies of 2024, Flagship Report, June 2024, World Economic Forum.*

Distinguishing elements of The Fourth Industrial Revolution

Indeed, compared to previous revolutions, the fourth Industrial Revolution is a far-reaching highly interconnected and global transformation, which means that it is not confined to any specific sector or industry, going beyond the merely productive and affecting multiple aspects of people's lives, making its impact as complex as it is rapid.

This speed is perhaps one of its key features compared to the three previous revolutions, which took decades to mature. In contrast, the fourth Industrial Revolution is unfolding at breakneck speed, accelerated by the very nature of the technologies involved, such as Artificial Intelligence, automation and quantum computing.

Similar to other Industrial Revolutions, there is concern regarding its impact on the labour market. However, as discussed below, unlike previous revolutions, it affects all types of occupations. The fourth Industrial Revolution not only enables the automation/robotisation of manual tasks but also supplements or replaces intellectual and/or creative jobs, requiring increasing efforts for adaptation, continuous training, and the acquisition of new skills.

Furthermore, while technological change in previous revolutions was focused on enhancing industrial processes and production efficiency, the current revolution is driven by massive data access and analysis. The key role played by information and Big Data in the fourth Industrial Revolution is introducing new challenges and debates that extend beyond questions of production. Specifically, on how to guarantee the privacy of individuals, information security and ethical consent in the collection of this data; in short, on the need to balance technological progress and individual rights.

Finally, a last distinguishing element of the fourth Industrial Revolution is the geopolitical context in which it is taking place. The previous Industrial Revolution and the early years of the current one took place in an environment characterised by globalisation, blurring the borders between countries and sectors thanks to the expansion of global value chains. However, geopolitical and economic changes in the last five years, especially in the aftermath of the pandemic, have led to a growing interest in economic security and strategic autonomy, resulting in a revision or reconfiguration of globalisation where protectionist ideas are gaining ground, a fact that will undoubtedly mark the direction and goals of the technological changes that are underway.

Artificial Intelligence as a major disruptor

Within this fourth Industrial Revolution, Artificial Intelligence is an iconic example of the convergence of technological advances in computing power, lowered costs, the availability of Big Data from multiple sources, online learning, and the application of algorithms[9]. AI gives machines the ability

9 Although the first steps in AI were taken in the mid-20th century by pioneers such as Warren McCulloch and Walter Pitts (the creators of artificial neuron models), Alan Turing (the Turing Test to determine

to perform tasks that until now relied on human intelligence, such as reasoning, learning or creativity, and it does so on the basis of mathematical/statistical, logical, computer and linguistic knowledge, among others, creating algorithms and models that, after prior training, imitate or even improve certain human cognitive functions[10].

More precisely, the EU's Artificial Intelligence Act[11] defines AI systems as a "machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and 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." The EU Regulation itself underlines the need for the concept of AI to be harmonised at a global level in order to ensure legal certainty and facilitate international convergence and broad acceptance, whilst making room for necessary flexibility to accommodate rapid technological developments in this field.

Currently, the generative version of AI (GenAI)[12] has attracted the most interest since the launch of ChatGPT in November 2022, a GenAI chatbot. GenAI generates new and original content from existing data, such as images, text, sound or video, using machine learning techniques such as artificial neural networks which learn from the information/data and produce seemingly realistic and coherent content. The disruption caused by GenAI is such, both in terms of its scope and its extremely rapid implementation, that it has even led to debate on whether we are facing a new Industrial Revolution. Its capabilities are extraordinary and increasingly sophisticated, and while it could benefit different sectors and areas of society, it also presents risks and challenges[13] (Figure 2).

whether a machine had intelligent behaviour indistinguishable from human behaviour) and John McCarthy (who coined the term in 1956 and developed the first AI programming language), it was not until the 20th century that the advances required for its rapid development have converged. The high availability of large amounts of data, advances in processing power (hardware), and the development of AI algorithms and deep learning models have enabled the exponential development of AI.

10 COTEC, *Uso responsable de la IA Generativa* (Responsible Use of Generative AI), February 2024.

11 Regulation 2024/1689

12 There are many different types of AI and applications, for example: virtual assistants, content recommendations, self-driving cars, chatbots, facial recognition, machine translation, predictive analytics, video games, AI in medicine or content generators.

13 COTEC, *op. cit*.

FIGURE 2. GENERATIVE ARTIFICIAL INTELLIGENCE: POTENTIAL AND CHALLENGES

Capabilities of GenAI

- Create high quality and diverse content, which can be used for creative, educational or informational purposes. For example, GenAI can create images, text or sounds that do not exist, but are plausible and appealing, or which can be used to illustrate or explain concepts or ideas.
- Generate synthetic tabular data, which enables the creation of new information such as sales data, customer data, production data, etc., that bears a statistical resemblance to the data on which it has been trained. This makes it possible to expand the available samples, generate extreme-case scenarios or even overcome privacy constraints by producing non-identifiable information
- Supplement or replace human labour in data-, time- or resource-intensive tasks such as translation, summarising, sorting or reporting. For example, GenAI can translate texts from one language to another, summarise the contents of a document, classify images according to their subject matter, or generate reports from data.
- Improve user experience and customer satisfaction by offering more personalised, interactive services tailored to the needs and preferences of each user. For example, GenAI can make appropriate and relevant responses to users' queries or demands, or create content that matches their tastes, interests or emotions.
- Facilitate access and democratise information, knowledge and culture, by enabling the creation and sharing of content in different languages, formats and formats and styles. For example, the GenAI can create content in minority languages or in different genres or artistic styles or adjust it to different levels of understanding.
- Encourage innovation and research by opening new possibilities and challenges for scientific, technological and artistic development. For example, the GenAI can create content that inspires new ideas, solutions or creations, or raises new problems, questions or hypotheses.

Risks and challenges

- Generate false, misleading or manipulated content, which may affect the veracity, credibility and trustworthiness of information, as well as the reputation, privacy and security of individuals and organisations. For example, GenAI can create images, text or sounds that show or say things that are not true, distort reality, or that attempt to influence people's opinions or behaviour
- Create or amplify biases, discriminations or inequalities, which may harm the most vulnerable or marginalised groups or individuals, or which may favour particular or ideological interests. For example, GenAI may create content that reflects or reproduces stereotypes, prejudices or injustices that exclude or harm certain individuals or groups, or which promote or justify certain agendas or worldviews
- Reduce or limit creativity, originality or human diversity by replacing or imitating the work of creators, or by generating homogeneous or standardised content. For example, GenAI may create content that copies or plagiarises the work of others, does not contribute anything new or different, or follows repetitive or predictable patterns or formulas
- Cause or exacerbate ethical, legal or social conflicts, dilemmas or problems by generating content that may be offensive, inappropriate, illegal or harmful to people or to the environment. For example, GenAI may create content that violates rights, norms or values; causes upset, displeasure or outrage; or leads to risk, threat or harm
- Hinder or impede the control, oversight or regulation of GenAI by generating content that may be difficult to detect, attribute, verify or correct. For example, GenAI may create content that is mistaken for real content, without knowing who created it or for what purpose, which cannot be checked or verified, or cannot be modified or deleted

Source: COTEC, *Responsible Use of Generative AI*, February 2024.

2. Economics and technological change. Impact on major macro-variables

The potential of the technologies involved in this fourth Industrial Revolution has been the focus of much academic debate and analysis over the last decade, which from the outset has focused on the potential impact of digitalisation on productivity and economic growth.

Discussions on the potential for technological change

The Economic and Social Council (ESC) echoed these debates in 2017 in its *Report on the digitalisation of the economy*[14], where it pointed out the enormous potential of the technological change that was taking place and which, at that time, was embodied in the expansion of digital infrastructures, the generalised network access and interconnection, the exponential increase in computing capacity, and the sophisticated processing of large-scale data, as well as advances in Artificial Intelligence and accelerated automation. Regarding the potential impact on productivity, it pointed out that this was uncertain and unpredictable, also considering that technological change is a dynamic and continuously evolving process.

In 2021, in its update of the previous report[15], the Economic and Social Council (ESC) extended the debates on the potential of technological change to the risks posed by the breakthrough of Big Data, the penetration of IoT in everyday activities, the high information processing capacity and the developments of Artificial Intelligence on the privacy of personal and business data; all of it with implications beyond the strictly economic, with social but also geopolitical consequences, as the "power of data" and the resulting "economies of scope" enhanced the technological hegemony of countries or companies and the consequent need to boost cybersecurity and address the ethical limits of digital developments.

Thus, the analysis of the macroeconomic impact of technological change and, especially of the most disruptive technologies, is a constant line of research that seeks to explore the extent to which the impact of these technologies justifies the discussion regarding a new Industrial Revolution on par with the steam engine or electrification.

All of this is based on the consideration that the impact of technological development on macro-economic variables takes time and occurs over several phases: a first phase of innovation-invention resulting in an initial increased efficiency that gives a glimpse into potential medium-term impacts; a second phase of implementation that requires time to exploit the inventions and achieve widespread deployment until general purpose technologies[16] are achieved, producing efficiency gains through diffusion

14 ESC (2017), *Digitalisation of the Economy*, Report 03/2017.

15 ESC (2021), *Digitalisation of the Economy*, Report 01/2021.

16 General purpose technologies have three defining characteristics: 1) they tend to permeate all sectors and social spheres, 2) they are subject to systematic improvement processes that reduce their cost, and 3) they generate constant innovation in institutions, processes and products.

–network effect–; and a third phase of consolidation that would imply, once the innovation is established, changes in organisation, growth patterns, consumption patterns and business models. Evidence from previous innovations suggests that a ceiling on long-term effects would be reached with this last phase.

However, it should also be noted that this efficiency gains associated with technological change have coincided over time with very moderate developments in productivity, leading to the so-called "productivity paradox" that has been noted for over a decade.

There are several explanations behind this apparent contradiction[17]. The first deals with measurement problems surrounding the digital economy[18], as although estimates of its added value in terms of GDP have improved over the years, this is not the case with new technological developments and, above all, with the resulting productivity gains, to capture its real contribution in terms of well-being. The second emphasises the time lags associated with major technological revolutions[19], and points to the importance of investment in intangible assets for the full deployment of innovations[20]. Precisely, the importance of investment in intangible assets supports the third explanation for lower productivity growth, due to the unequal adoption and use of digital advances in the production network. In fact, although micro-economic studies at company level confirm the existence of a positive relationship between digitalisation and productivity[21], the same cannot be said in aggregate terms, with more scattered productivity between sectors, companies, individuals or territories, which diminishes the positive effect that digital transformation may have on aggregate productivity.

The macroeconomic impact of AI

In the face of the continuing debate on the impacts of technological change, works within the last three years have focused on analysing the potential impact of the most disruptive developments, especially AI, on the global economy, as well as their limitations and risks. Their transformation potential is undeniable, although the macro-economic impacts are unpredictable and it is difficult to

17 ESC (2021), *Digitalisation of the Economy, Report...;* op. cit.

18 In fact, Adigital estimates put the direct impact of the digital economy in Spain at 12.9 percent of GDP in 2024, almost four percentage points more than in 2019, reflecting continued growth in its contribution to GDP in aggregate terms. See Adigital (2025), *Economía digital en España*, 5th edition, May.

19 Delays that may have a triple origin: the time elapsed between the initial innovation and its implementation and profit-generating capacity; the time required for the investment derived from the innovation to have a weight in the existing capital and, therefore, in aggregate productivity; and the need for the full potential of the innovation to be exploited through other supplementary activities and the strengthening of intangible capital (organisational changes and training of human capital).

20 The "productivity J-curve" describes how new technologies, especially general-purpose technologies, deliver productivity gains only after a period of investment in complementary intangibles, such as business processes and new skills. See Brynjolfsson, E. et al. (2021), "The Productivity J-Curve: How Intangibles Complement General Purpose Technologies", in *American Economic Journal. Macroeconomics*, vol. 13, no. 1.

21 Gal P. et al. (2020), *Digitalisation and productivity: In search of the holy grail – Firm-level empirical evidence from EU countries*, OECD Economics Department Working Papers No. 1533, OECD.

estimate to what extent, how and when the resulting efficiency gains and potential effects on productivity and economic growth will materialise, depending on the speed of progress, the diversity and development of applications, and their widespread deployment, and even whether they shall accelerate further or stagnate.

As with previous technological innovations, the automation of certain tasks and productivity improvements in certain occupations will have an impact on certain professions[22], again raising questions regarding the types of jobs at risk of being automated, not only routine and/or manual tasks but also cognitive and/or intellectual ones the workers that shall benefit or lose from AI development, effects on productivity, and how AI may complement certain tasks more efficiently. But even more important questions are now being asked about the capacity or limits of the human brain to perform very complex tasks[23]. The most recent developments of generative AI models even bring the debate to the question of whether this is a differential transformation with an exponential impact on growth or whether these technological advances and the efficiency gains derived from their implementation and diffusion will not reach the level of previous Industrial Revolutions [24].

In order to counteract the uncertainty associated with the development of AI, some experts propose scenarios with different rates of progress and degrees of automation of tasks – both in terms of quantity and time – which have different impacts on growth, productivity or employment, but which make it possible to visualise the potential opportunities and risks in each case and adopt policies accordingly[25].

Determining which AI development scenario is closest to the future requires continuous monitoring of indicators in multiple areas, ranging from performance testing of technologies or levels of investment for their development and adoption by the economy as a whole to the analysis of macroeconomic and labour market trends.

All of the above points to the difficulties and uncertainty of estimating the impacts of AI. Therefore, virtually all academic work seeks to estimate impacts in the relatively near term – within a ten-year horizon – considering that future developments are uncertain, not predetermined, and will depend to a large extent on the decisions and policies that are adopted today.

So far, the available empirical evidence envisages a very limited impact of AI as we are at an early stage of its adoption; even in countries with the highest AI penetration such as the US, there are no substantial productivity gains and many of the applica-

22 Acemoglu, D. (2024), *The simple macroeconomics of AI*.

23 Korinek, A. (2023) *Scenario Planning for an A(G)I Future*, IMF.

24 Gordon, R. J. (2016): *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War*. Princeton University Press.

25 Scenarios ranging from a conservative profile, assuming a path similar to that observed in recent decades, to other more aggressive scenarios, with much greater automation with different time horizons in the longer term (20 years) and even in the short term (5 years). See Korinek, A. (2023) *Scenario Planning...*, IMF.

tions generated do not necessarily have high added value. The fact that this impact is difficult to predict requires greater research efforts in order to overcome the asymmetry between the scale and speed of the emergence and deployment of these disruptive technologies, and the limited knowledge of their consequences.

Impacts on productivity and economic growth

A priori, as in previous technological innovations, the greatest impact of AI will come from the automation of certain tasks and improvements to the productivity of some workers in certain occupations which, based on Hulten's theorem, will result in aggregate productivity[26]. Depending on the degree to which jobs are exposed to automation, they may be transformed, new jobs may emerge, or there may be more complementary jobs. Thus, productivity gains would arise in different ways[27]: by the automation of some tasks; complementarity with tasks that have not been fully automated (access to better information or complementary inputs), by the deepening of automation, increasing the productivity of capital in tasks that are already automated, or the creation of new tasks thanks to AI. In the latter case, provided that the new tasks created generate positive effects, otherwise productivity would be affected[28].

But the main difference compared to previous technological innovations is that AI can achieve cognitive and "hard learning" tasks. In this case, growth in productivity, GDP and ultimately welfare would come both from efficiency gains in routine tasks and in intellectual and/or creative tasks (e.g. the production of ideas) and, consequently, from increased aggregate productivity and from the acceleration of innovation that comes with the incorporation of these disruptive technologies in all types of tasks (e.g. by providing better information to workers in their work experience). In fact, most innovation is generated in occupations that require high cognitive skills, so improving the efficiency of these types of tasks has great potential for generating greater innovation. In turn, faster AI-led productivity growth expand the production capacity of the economy and thus aggregate supply, which will materialise in an increase in potential GDP.

It is precisely the lack of indicators to measure cost savings in non-routine racks that makes it difficult to analysis the macro-economic impact of AI. In fact, the most recent research estimate clear impacts, but have a very wide range[29], depending on the starting assumptions considered, mainly with regard to the percentage of automation of tasks and occupations.

26 According to Hulten's theorem, aggregate productivity growth may be calculated as the weighted sum of individual productivities (in terms of average cost savings). See Hulten, Ch. (1978), "Growth Accounting with Intermediate Inputs", *The Review of Economic Studies*, vol. 45(3), pages 511-518.

27 Acemoglu, D. and Restrepo, P. (2019), "Artificial Intelligence, automation and work", in *The Economics of Artificial Intelligence: An Agenda*, Agrawal, A. et al (eds.).

28 Acemoglu, D. (2024), *The simple ...*; op. cit.

29 Brynjolfsson, E and Unger, G. (2023) *The Macroeconomics of Artificial Intelligence*, IMF.

FIGURE 3. ESTIMATES OF THE IMPACT OF AI (From the most prominent studies)

Studies	Year of publication	Geographical reference	Focus and conditioning factors	Assumption of % jobs/ tasks affected	Aggregate productivity (TFP) over 10 years (pp)	Labour productivity	GDP
Baily, Brynjolfsson y Korinek (FMI)	2023	USA				2.6 pp in 10 years	
McKinsey	2023	Global		*60-70%*		Growth between 0.5 and 3.4 pp over ten years	3-4 pp average annual growth of the world economy
Goldman Sachs (Briggs y Kodani)	2023	USA/global	Depending on the development of AI capabilities and speed of adoption.	2/3 of jobs automated by AI (300 million)	Productivity growth of 1.5 pp over 10 years in US and 1.3 pp globally		7% increase in overall GDP
Goldman Sachs (Briggs)	2024	USA		25% of tasks automated with generative AI	9.2% in ten years		15% growth in ten years
Acemoglu	2024	USA	Based on AI impact at task level. Automation and complementarity of tasks	20% of tasks exposed to AI and only 4.6% exposed to generative AI	TFP growth 0.71-0.55 over 10 years. With more restrictive assumptions 0.66 -0.53	Productivity improvement in low-skilled workers	Increase 1-1.5%
Aghion y Bunel	2024	USA	Based on the experience of previous technological revolutions		Growth of 0.8-1.3 pp per year for 10 years		€250-400 billion increase over ten years
			Applying the Acemoglu model with assumptions and own literature review		Growth of 0.07-1.24 pp per year for 10 years		
High Level Panel of Expert's Report to the G7	2024	G7	Depends on the degree of task automation and innovation.		Conclusions on existing estimates 0.1-1.2 pp per year		
OCDE	2024	USA			TFP growth between 0.25-0.6 pp	Growth in labour productivity between 0.4 and 0.9 pp	

Source: Authors' own based on the referenced works: OECD (2024), *Miracle or myth?. Assessing the macroeconomic productivity gains from Artificial Intelligence*; Martin Neil Baily. M et al, (2023), *Machines of mind:. The case for an AI-powered productivity boom*; Briggs, J. and Kodnani, D. (2023), *The Potentially Large Effects of Artificial Intelligence on Economic Growth*, Goldman Sachs Economics Research; Acemoglu, D. (2024), *The simple macroeconomics of AI;* Aghion, P. and Bunel, S. (2024), *AI and Growth:. Where Do We Stand?*

Therefore, a large part of academic literature of the topic has sought to estimate the microeconomic impact of automation on specific tasks and occupations and, from there, to infer aggregate effects for the economy as a whole (Figure 3). Although there are doubts regarding this methodology, it appears to be confirmed that AI systems capture and transmit part of the tacit knowledge of these tasks (knowledge, experience and search for solutions) that was previously only obtained through on-the-job experience[30].

The most optimistic positions estimate high productivity growth, especially due to the complementary use of AI in a high percentage of tasks performed by the majority of workers and its application in different fields and, consequently, positive impacts on the growth of activity, even reaching, as Goldman Sachs points out, global GDP growth of 7 per cent over a ten-year horizon[31].

At the other end, there are more pessimistic stances that, based on models analysing the impact of AI on productivity at the level of sectors, activities and even tasks, anticipate that productivity gains will not be so great and, on the other hand, there may be significant risks associated with these new technologies. In general, these stances do not consider the prospective effects of automation on the production of ideas, which is key to developing disruptive models such as generative AI.

Within this reduced impact approach, the work of Daron Acemoglu stands out, who points out that economic theory and available data justify a cautious stance on the future impacts of AI[32], based on estimates of only 4.6 per cent of replaceable tasks, of which, moreover, a quarter would be "hard-to-learn" tasks. Based on these assumptions, estimates of total factor productivity (TFP) growth over the next 10 years would be between 0.53 and 0.71 per cent, and the derived GDP growth, considering an increase in capital stock proportional to the increase in TFP, would reach a range of 0.9 to 1.5 per cent, and could even reach 1.8 per cent if the increase in investment were similar to that in previous waves of innovation. Furthermore, he considers that some of the tasks generated by AI may have a negative social value (e.g. in the use of social networks), which would lead to decreased welfare.

Most studies take an intermediate stance, estimating a more moderate impact that depends on its individual effect on jobs, based both on whether AI leads to substitution, displacement or complementarity of tasks and the changes that take place in this sense as AI develops, and on delays in its adoption by the productive system or an uneven deployment throughout the business sector[33], elements that have been pointed out above in relation to the productivity paradox. In this regard, drawing on parallels

30 Brynjolfsson, E. et al. (2023) *Generative AI at Work*, NBER

31 Briggs, J. and Kodnani, D. (2023), *The Potentially Large Effects of Artificial Intelligence on Economic Growth*, Goldman Sachs Economics Research.

32 Acemoglu, D. (2024), *The simple ...*; op. cit.

33 Zolas, N et al. (2021) Advanced technologies adoption and use by US firms: evidences from the annual business Survey, NBER WP 28290.

between the AI revolution and past technological revolutions, Aghion and Bunel[34] estimate an aggregate productivity growth impact of between 0.8 and 1.3 percentage points per year over the next decade, and applying Acemoglu's task-based approach to their own assumptions, they estimate an increase of 0.68 percentage points over ten years on average. In the same vein, the OECD[35], has pointed out that AI will play a key role in future economic growth but that there is also high uncertainty regarding the magnitude of this impact. The estimated annual TFP growth is in the range of 0.25 to 0.6 percentage points.

It may therefore be concluded that there is a very wide range in the estimates of the impact of AI on annual aggregate productivity growth and, consequently on GDP, depending on the starting constraints and assumptions, and that the main impact will be via the automation of tasks and skills and, in this sense, the key element is the percentage and type of tasks that may be affected[36].

In any case, advances in AI must be disseminated throughout the economy for productivity gains to materialise. This takes time, as these advances must be adopted and deployed by all firms, including small and medium enterprises, and some may be slow to adopt these new advanced technologies or lack the skills to make them profitable. The demand for investment, and especially in intangible assets, to improve firms' adoption capacity will provide a boost to aggregate demand, although the potential productivity gains will not appear immediately.

Other macroeconomic impacts

Beyond the impact on labour productivity, AI will have an impact on the labour market, analysed in detail in the space devoted to this topic in Chapter 2 of the 2024 Report of the ESC, both in terms of job creation and wage growth, as has been the case with previous technologies. However, setting it apart from previous technologies, this impact will be on lower as well as higher-skilled jobs, tasks and skills, which will condition the effects on job polarisation, depending on whether it boosts the complementarity of the tasks performed, rather than their replacement or the emergence of new tasks. The IMF notes that almost 40 per cent of global employment and 60 per cent in the most advanced countries is exposed to AI[37].

In turn, the distribution of the resulting productivity and wage gains across workers and demographic groups may have an effect on inequality[38]. Empirical evidence

34 Aghion, P. and Bunel, S. (2024), AI and Growth: Where Do We Stand?,

35 Filippucci, F et al. (2024), *Miracle or myth? Assessing the macroeconomic productivity gains from Artificial Intelligence*, OECD Artificial Intelligence Papers, November.

36 There is some consensus that around 60 per cent of tasks will be affected in the most advanced countries (up to 65 per cent in the case of Spain according to the HispanIA 2040 Report), rising to 80 per cent in the United States, where there is greater AI penetration. See Eloundou, T. et al. (2023) *GPTs are GPTs:. An Early Look at the Labor Market Impact Potential of Large Language Models.*

37 IMF Blog, Georgieva, K. (2024) AI Will Transform the Global Economy. Let's Make Sure It Benefits Humanity, 16 January 2024.

38 Brynjolfsson, E and Unger, G. (2023) *The Macroeconomics of Artificial Intelligence*, IMF.

suggests that ICTs may have contributed to job polarisation between high- and low-income workers and, consequently, to inequality. But in the case of AI, the positions are more ambiguous: from those who argue that inequality may increase if the worker substitution effect is predominant, to those who argue that this effect should not occur and that the impact of AI should be distributed more evenly by income level and, therefore, inequality should not increase, since workers with lower qualifications or experience will improve their productivity[39].

Different positions are also put forward regarding the impact of AI on firm-level inequality depending on the degree of AI adoption and the possibility of greater industrial concentration[40]. The trends towards greater concentration are underpinned by the fact that only the largest companies have greater capacity to invest in and use big data and are able to make an intensive use of AI, being more productive, profitable and larger than their competitors. The evidence proves that it is very difficult to counter market concentration by large digital players and there is reasonable concern that dominant digital firms have strong motives to engage in anti-competitive behaviour on a global scale that is difficult to regulate or control. However, there are also positions that predict less concentration and more competition with a level playing field, as AI develops open source models that are widely available and accessible to all companies.

With regard to other macroeconomic variables, less attention has been paid. For example, the widespread adoption of AI could have an impact on inflation dynamics[41], since, a priori, productivity improvements and cost savings may have a deflationary effect on the economy, although if it is anticipated that productivity will be affected, inflation may rise[42]. AI could also condition the upward trend of long-term real interest rates (which are positively correlated with productivity improvements), with consequent effects on financial stability. Indeed, the effects on financial stability are seen as two-way, since some risks would be mitigated by facilitating more effective risk management and allowing for more liquidity in the markets, but at the same time some opacity may be generated, making supervision more difficult and increasing vulnerability[43].

Finally, although it is dealt with in greater detail in the section devoted to this issue in Chapter 3 of the 2024 Report of the Economic and Social Council (ESC), the impact of AI in terms of growth cannot ignore the environmental problems posed by its development, calling into question the estimated welfare gains. In this regard, while there is a tendency to point out that AI can help address current climate emergencies

39 Brynjolfsson, E. et al (2023) *Generative AI at Work*, NBER, WP 31161 and Rockall, E et al. (2024), *AI Adoption and Inequality.*

40 Brynjolfsson, E. and Unger, G. (2023), *Macroeconomics …*, IMF.

41 BIS (2024), *Annual Economic Report 2024*, June.

42 Aldasoro, I. et al. (2024) *The impact of artificial intelligence on output and inflation,* CEPR Discussion papers 19604, October.

43 IMF (2024), *Global Financial Stability Report:. Steadying the Course: Uncertainty, AI and Financial Stability*, October.

by making available more data and information, there are significant negative impacts due to the infrastructures associated with its development (data centres required to train, host and run AI models), which require a huge amount of resources – intensive consumption of electricity and water, critical minerals and rare earths – and generate a high volume of hazardous waste[44]. The absence of internationally standardised procedures to measure this cost and the environmental footprint generated makes it difficult to estimate what this impact may be, although there is growing consensus on the need to take it into account and to try and draw up measures to minimise it[45].

In short, beyond the above-mentioned macroeconomic impacts, AI, and especially generative AI also have significant effects on employment and the labour market, as well as social impacts, which must be taken into consideration as a whole when assessing its contribution beyond productivity gains and growth. This is the subject of the sections referred to in Chapters 2 and 3 of the 2024 Report of the Economic and Social Council (ESC).

3. Development of Artificial Intelligence. A comparative analysis

The strategic importance of artificial intelligence (AI) as a key driver of economic and social development has been recognised in recent years. Most economies have allocated significant resources, designed policies and implemented strategies in order to remain at the forefront of this technological field.

According to the *Global AI Index*[46], a composite indicator that compares the AI capabilities of the world's leading economies, the United States and China have headed the list for the past five years and are leaders in both innovation, deployment and investment in AI (Graph 1); however, the US economy's score (100) is significantly higher than China's (54).

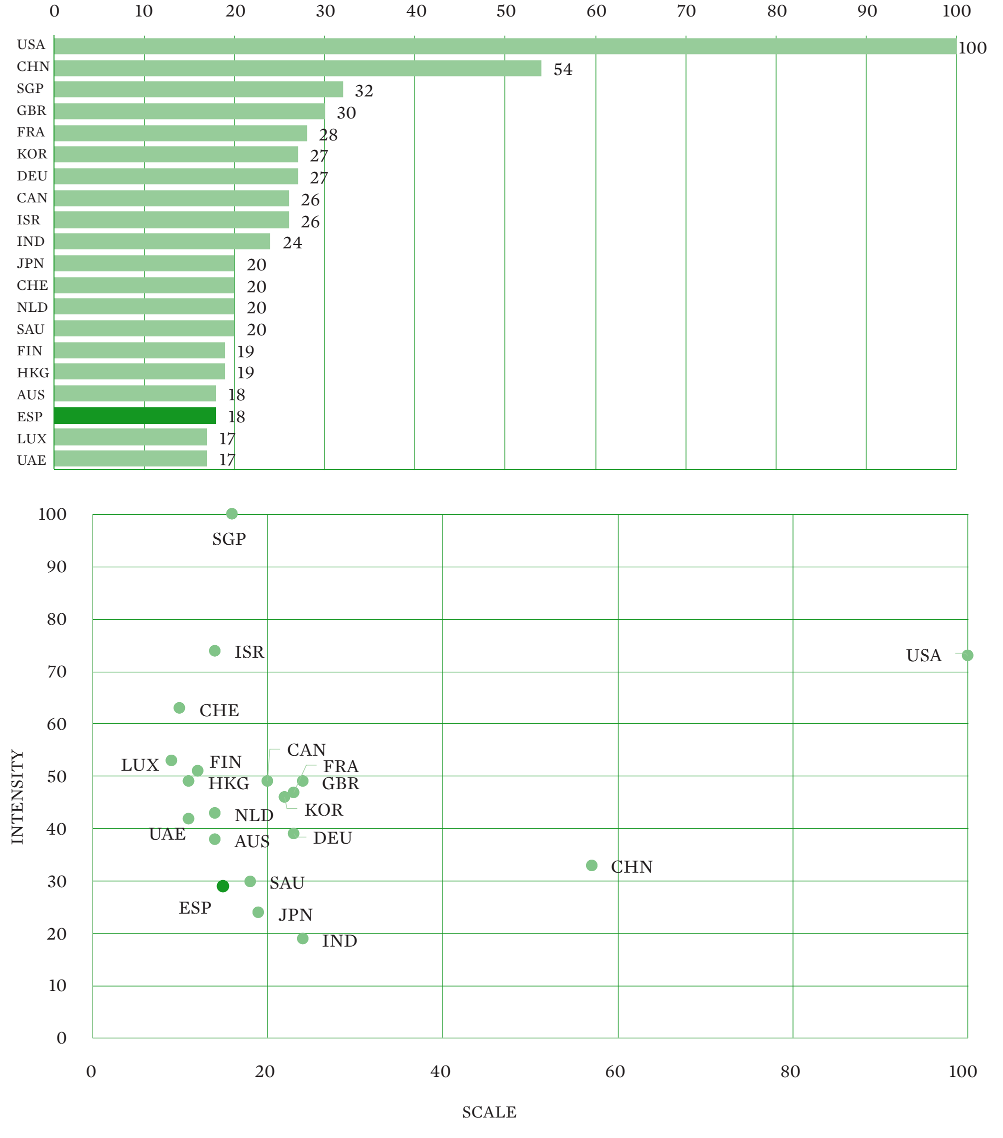
They are followed by certain EU economies with slightly lower scores such as France (28), Germany (27), the Netherlands (20), Finland (19), Spain (18) and Luxembourg (17). From a dynamic perspective, the index finds that, since the advent of generative AI, France has improved its score considerably, while Canada and Israel have slipped down the ranks.

44 When dealing with the issue of climate change, the previous edition of this Annual Report explained precisely how the digital sector must make an effort to ensure that its positive contribution to the fight against climate change is not diminished by its direct impact on the environment. See ESC (2024), *Memoria sobre la situación socioeconómico y laboral. España 2023,* pp. 152-153.

45 United Nations Environment Programme (2024), *Artificial Intelligence (AI) end-to-end:. The Environmental Impact of the Full AI Lifecycle Needs to be Comprehensively Assessed*, Policy Brief, September.

46 The *Global AI Index* (2024) assesses the degree of development of Artificial Intelligence in 83 countries, through 122 indicators grouped under three analytical pillars: Implementation, Innovation and Investment. The *Global AI Index* developed by Tortoise has been used by the World Economic Forum or the Spanish strategy HispanIA 2040 to assess the position of economies in the AI race. There are other global indicators such as the IMF's *AI Preparedness* or Oxford's AI Readiness Index whose methodologies enable the identification of areas for improvement, but do not classify countries.

GRAPH 1. GLOBAL ARTIFICIAL INTELLIGENCE INDEX, 2024



Note: This classification should be approached with caution as the race for innovation in AI is speeding up and new developments may lead to substantial changes in AI.
Source: Tortoise, *Global AI Index*, published on 19 September 2024.

Additionally, the index analyses national AI capacity through absolute and relative measures, with the final index score being a combination of both. It distinguishes "scale", which measures a country's AI capacity in absolute terms (where the US and China are leaders), from "intensity", which measures capacity in terms of the size of its economy or population (where Singapore, Israel and Switzerland are in the lead). Although far from the positions held by the United States or China, Spain ranks among the economies with a relatively good AI performance commensurate with the size of its economy.

In order to assess countries' level of preparedness to adopt AI – but without taking into account, in this case, leadership in invention – the IMF proposes an AI Readiness Index[47] (Graph 2). The right level of readiness lets us optimise the transformative potential of AI, i.e. maximising benefits while simultaneously mitigating the risks inherent in its implementation. The index consists of a set of indicators organised into four categories: digital infrastructure, innovation and economic integration, human capital and labour market policies, and regulation and ethics, all of which are interconnected. Indeed, it is an economy's collective performance in these areas that determines its AI readiness.

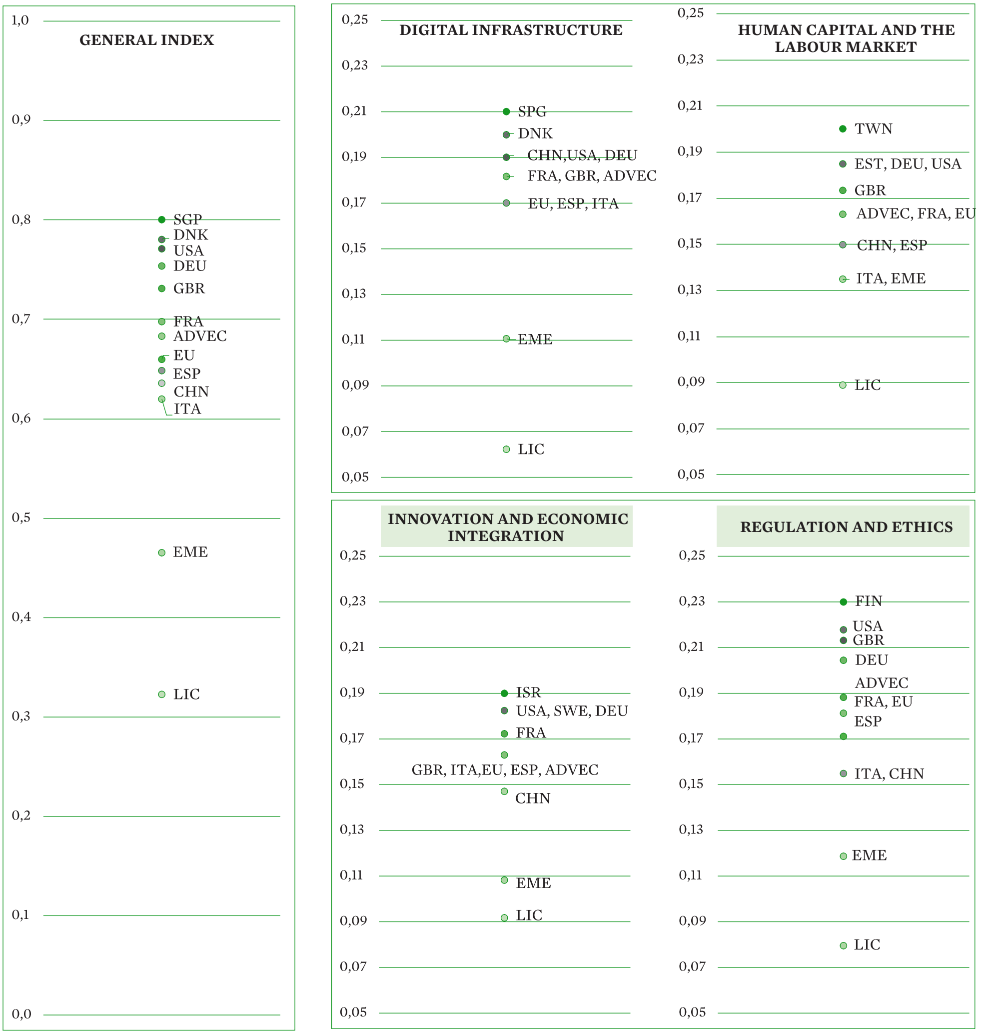
Clearly, the prior existence of a high-quality and wide-ranging (e.g. territorial) digital infrastructure is key, but it will only be effective if there is sufficient talent for its use, hence the relevance of human capital and labour market policies in ensuring digital skills and guaranteeing a fair transition in employment. Talent and infrastructure are key to innovation and economic integration, i.e. to foster technological development and prosperous external economic relations. Above all, there is a continuing need to adapt legal frameworks to new digital business models and to ensure ethical AI governance based on a fair social model and democratic principles. The biggest differences in readiness between countries in terms of their level of development are in the provision of digital infrastructure and in the existence of the aforesaid regulatory framework.

The EU is at 66% of the optimal level of preparedness to adapt to AI, and within the EU, Denmark, the Netherlands, Estonia, Finland and Germany are above 75%. Spain's preparedness for the challenges posed by AI is about the same as the EU average (65 per cent) and somewhat lower than the average for advanced economies (68 per cent). Although there is still room for improvement, Spain's digital infrastructures or its innovation and economic integration offer an environment for AI development similar to that of the EU average or of advanced economies. However, Spain requires more efforts in human capital preparation and labour market policies, as well as in regulation and ethics[48].

47 The AI Readiness Index (AIPI) assesses the level of Artificial Intelligence readiness in 174 countries, based on macro-structural indicators covering digital infrastructure, human capital, labour policies, innovation, economic integration, and regulation and ethics. The data is sourced from 8 international institutions, such as the World Bank and the ILO. Source: Cazzaniga et al. 2024. "Gen-AI: Artificial Intelligence and the Future of Work". IMF Staff Discussion Note SDN2024/001, International Monetary Fund, Washington, DC

48 These results are consistent with those offered by successive editions of the European Commission's Digital Economy and Society Index (DESI), which have been discussed by this Council.

GRAPH 2. ARTIFICIAL INTELLIGENCE READINESS INDEX



Source: Authors' own based on IMF *AI Preparedness Index* (2023 data).

AI strategies: EU and Spain

Since 2018, with the launch of the European Strategy for Artificial Intelligence[49], the EU has been working to promote AI, ensuring that it is consistent with EU values and principles. In 2020, the European Commission presented the White Paper on AI[50], which established two key points: an ecosystem of excellence, aimed at fostering innovation and competitiveness, and an ecosystem of trust, focused

49 COM (2018) 237 final, 25 April, on Artificial Intelligence for Europe.
50 COM (2020) 65 final, 19 February.

on ensuring a regulatory framework that mitigates the risks associated with AI. In 2021, it presented a package on AI including a Communication to promote a European approach[51], the revision of the Coordinated Plan[52] and commenced work on a comprehensive regulatory framework.

In 2024, the Artificial Intelligence Act[53] was finally enacted, constituting the first comprehensive standard for AI worldwide. It classifies AI applications into three risk categories: those posing an unacceptable risk, which are prohibited (e.g. subliminal manipulation or mass biometric surveillance), those that pose a high risk, which are subject to security and transparency requirements (e.g. related to health or personal finance), and those of limited and minimal risk, with some transparency obligations. Also in 2024, the European Commission adopted the AI Innovation Package, which provided for financing mechanisms to develop generative AI through tools such as "Horizon Europe", fostering AI talent, supporting startups and expanding companies through funding and venture capital, developing a European data space and boosting the use of AI in strategic sectors such as health, biotechnology and mobility, through the *GenAI4EU Initiative*.

In early 2025, at the AI Action Summit, the European Commission presented the *InvestAI* initiative to mobilise €200 billion for AI investment, including a new €20 billion European fund for AI gigafactories.

In this context, Spain has been developing its own AI promotion strategy, with the first major milestone being the 2020 National Artificial Intelligence Strategy. Four years later, a new strategy was approved in compliance with the Recovery, Transformation and Resilience Plan (PRTR): the Artificial Intelligence Strategy 2024, which provides continuity, reinforces, and adapts the 2020 strategy to new technological advances, and has 1.5 billion euros mainly from the PRTR and its addendum for its development. In fact, the promotion of Artificial Intelligence is also included in the Digital Spain Agenda 2026 as a key cross-sectoral element for transforming the production model and boosting the growth of the Spanish economy. Furthermore, in line with the EU's Artificial Intelligence Act, a Preliminary Draft Bill on AI was presented in March 2025, which sets out requirements for the transparency of AI-generated content and sanctioning measures.

51 COM (2021) 205 final.
52 In 2021, COM (2021) 102 final, the coordination plan for national strategies to boost investment in AI was revised (COM (2018) 795 final).
53 Regulation (EU) 2024/1689 of 13 June 2024 laying down harmonised rules on artificial intelligence (...)

4. Situation, challenges and opportunities for the Spanish production sector

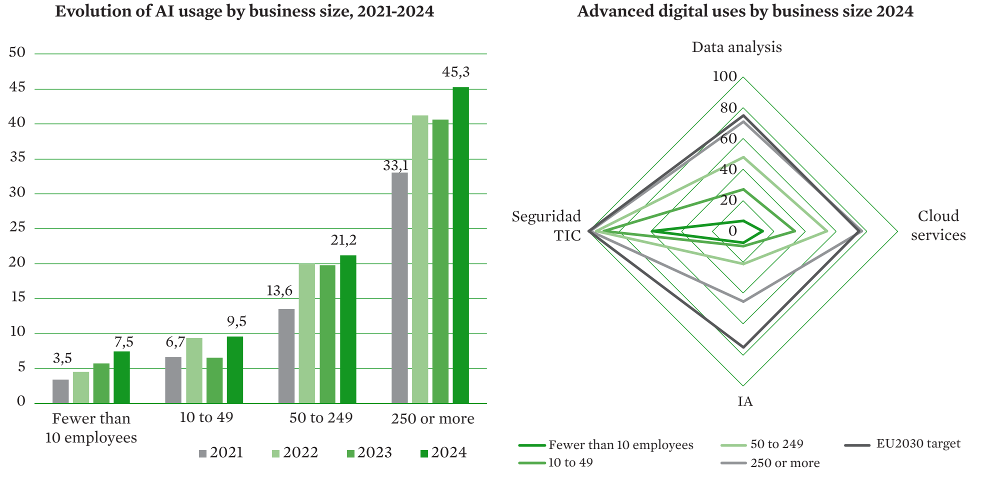
AI in the Spanish production sector

In recent years, the Spanish business sector has made progress in integrating digital technologies. In fact, in its latest Digital Decade Report (2024), the European Commission highlighted the notable growth in AI adoption by Spanish companies, which has also led to Spain being ranked above the EU average, in a list led by Denmark, Sweden and Belgium, where more than a quarter of companies with 10 or more employees use AI.

Despite this progress, there is still a long way to go for the Spanish production sector, especially in the case of SMEs, in terms of adopting advanced technologies such as Artificial Intelligence, the use of the cloud or massive data analysis, and also with regard to improvements in cybersecurity. It should be recalled that the EU has set a target for 2030 in its European Digital Decade plan that 75 per cent of companies will have adopted cloud services, Big Data, and Artificial Intelligence.

That goal is still a long way off. According to the most recent data from the National Statistics Institute's (INE) Survey on the use of ICT and e-commerce in companies, in 2024, only 12.4 percent of Spanish companies with 10 or more employees were using Artificial Intelligence (Graph 3). Use of this technology increases with the size of the company: only 7.5 per cent of micro enterprises used AI, compared to 9.5 per cent of

GRAPH 3. ADVANCED DIGITAL USES OF SPANISH COMPANIES AND EVOLUTION OF AI USAGE
(Percentage of companies)



Note: The EU does not set a specific target for ICT Security, 100 per cent has been considered as the optimal target for the graphical overview.
Source: Compilation based on National Statistics Institute's (INE) Survey on the use of ICT and e-commerce in companies (1st quarter 2024), October 2024.

small enterprises, 21.2 per cent of medium-sized enterprises and 45.3 per cent of large enterprises[54].

In terms of branches of activity, service companies make the greatest use of AI at 15.6 per cent, while only 4.5 per cent of construction companies employ it (Graph 4). However, when analysing AI usage according to the size of firms in each sector, large industrial firms are the most intensive users of AI, at 48 per cent, followed by services and construction. Amongst smaller firms, small service firms are the biggest AI users, accounting for 12.7 per cent, while at the other end of the scale, small construction firms account for only 3.7 per cent.

In fact, within the services sector, two branches: information and communication services and professional, scientific and technical activities are the ones that make the greatest use of AI, 46.6 and 26.1 per cent on average, respectively. It should be recalled that the dynamism displayed by both branches in recent years explains part of the growth in Spain's GVA, the structural change in its production sector well as the positive balance in international trade in services. In particular, 70.1 per cent of large companies in the information and communications services sector use AI. For small companies in the same sector, AI adoption is at 40 per cent, a figure that exceeds the AI usage in large companies in other sectors.

It is clear, therefore, that the adoption of Artificial Intelligence in companies varies significantly according to their size and sector of activity, and that there is no one-size-fits-all solution. Instead, AI's versatility allows it to adjust to each context and to the specific needs of each company in order to better exploit its potential.

In fact, the National Statistics Institute's survey itself classifies the different uses of AI in companies, highlighting the breadth of the concept and the diversity of its applications. Thus, when assessing AI integration in enterprises, the survey refers to systems that use technologies such as text mining, computer vision, speech recognition, natural language generation, machine learning and deep learning to collect and/or use data to predict, recommend or decide, with different levels of autonomy, the best action to achieve specific objectives.

Thus, two types of systems may be distinguished. On one hand, Artificial Intelligence systems that may be exclusively software-based, such as chatbots and virtual business assistants based on natural language processing, facial recognition systems based on machine vision or voice recognition systems, machine translation software or data analysis based on machine learning, among others. On the other hand, there are systems embedded in devices, such as autonomous robots for warehouse automa-

54 Note: Spanish micro-enterprises (0 to 9 workers) account for 94.3 per cent of companies, 34.4 per cent of employees, and 25.8 per cent of GVA (2023). Small enterprises (10-49 employees) account for 5.0, 19.9 and 17.1 per cent respectively. Medium enterprises 0.6, 13.3 and 16.4 per cent; and large ones (more than 250 workers) 0.1 of the number of companies, 32.3 of workers, and 40.6 per cent of the GVA. Source: *European Commission, 2024 SME country fact sheet, Spain.*

GRAPH 4. AI USAGE BY PRODUCTION SECTORS IN SPAIN, 2024 (Percentage of companies)

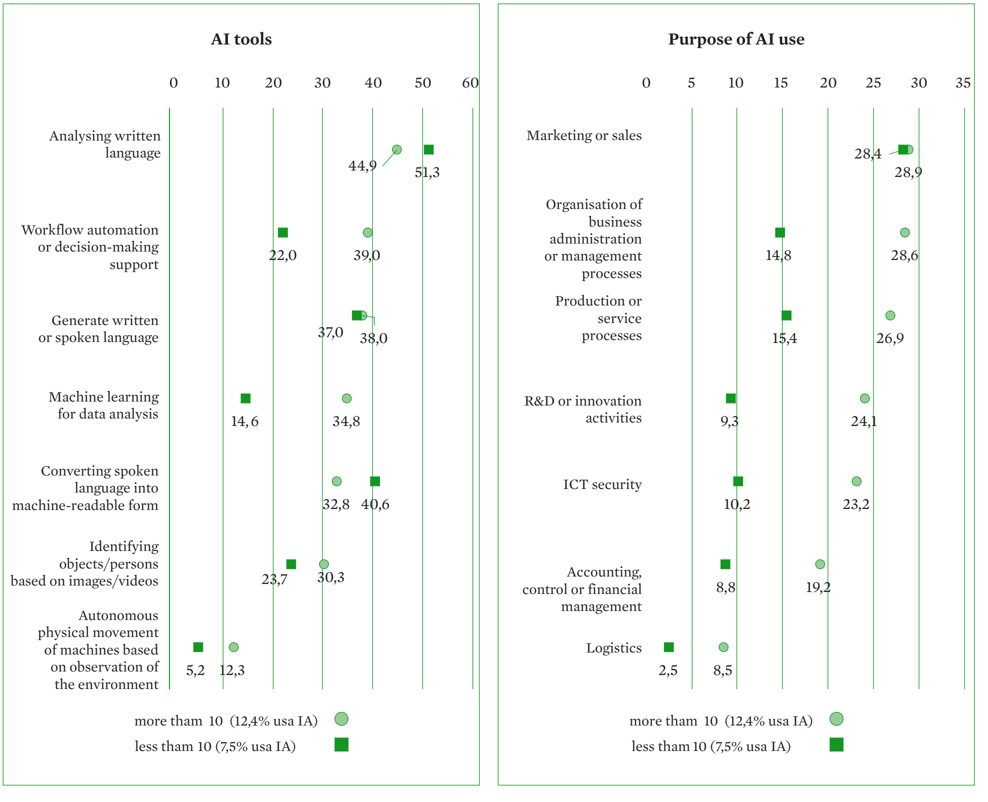
Note: The National Statistics Institute (INE) only provides sectoral breakdowns for enterprises with more than 10 employees. The average AI usage for each sector is shown in brackets below the major sectors.
*: Excluding food and beverage services and financial services.
Source: Compilation based on INE Survey on the use of ICT and e-commerce in companies (1st quarter 2024), October 2024.

tion or production assembly work, or autonomous drones for production monitoring or package handling[55].

Of all these solutions, the AI tool most used by Spanish companies is the analysis of written language, both in micro-companies and in the rest (Graph 5). As for other technologies, smaller companies rely mainly on the conversion of spoken language into machine-readable formats and the generation of written or spoken language. The rest of the Spanish business community makes greater use of workflow automation and decision-making support, as well as written or spoken language generation.

Within the Spanish business world, the main application of AI is in marketing and sales activities, both in micro-enterprises and in larger companies (Graph 5). This is

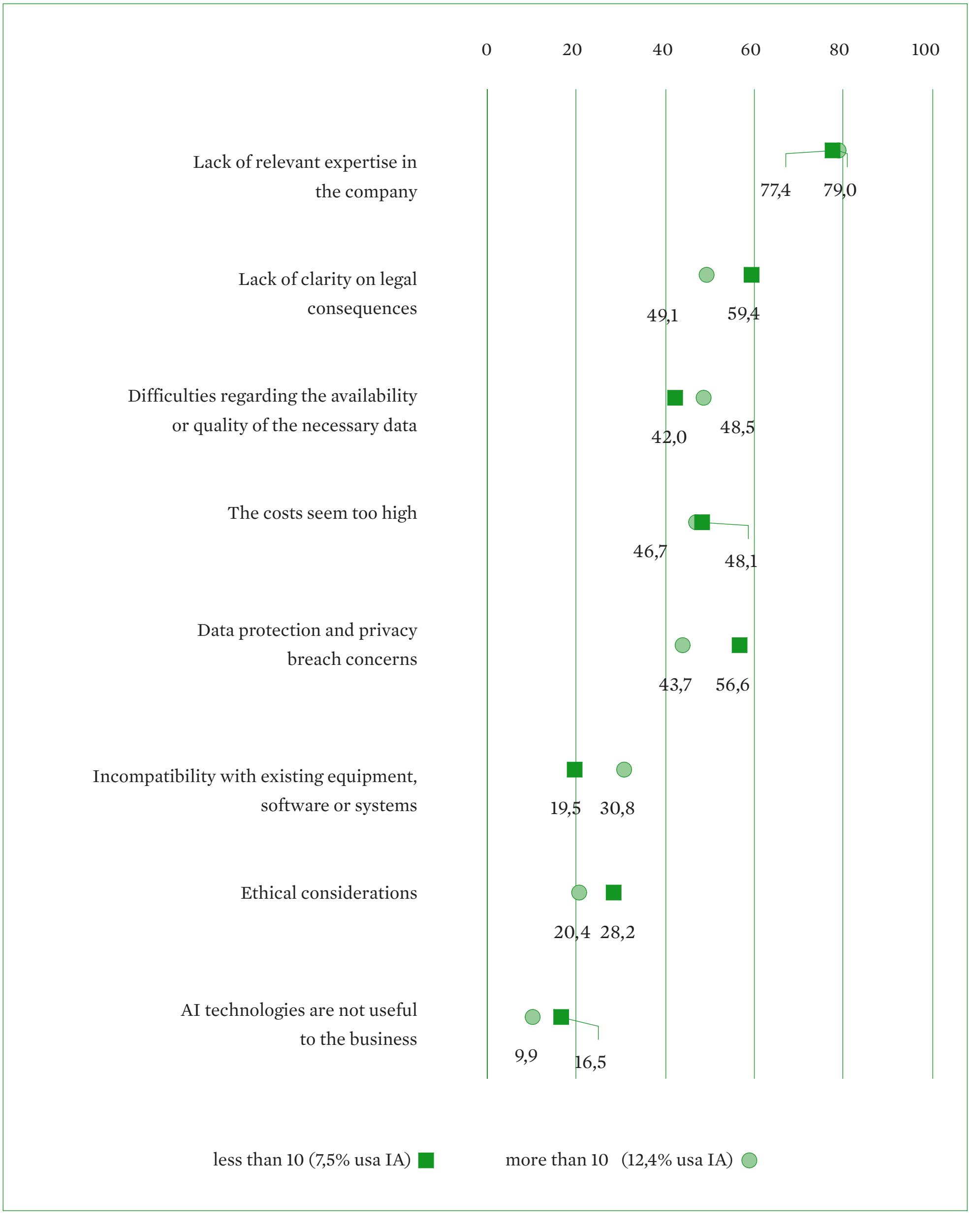
GRAPH 5. AI TOOLS AND PURPOSE OF USE BY SPANISH COMPANIES, 2024 (% of companies using AI)



Source: Compilation based on INE Survey on the use of ICT and e-commerce in companies (1st quarter 2024), October 2024.

55 In the latest survey (2023-2024), the National Statistics Institute (INE) further clarified that the concept includes the use by enterprises of large language models (LLM) such as ChatGPT (OpenAI), Bard (Google), Llama (Meta), Bing Chat (Microsoft), Copilot (Github), among others.

GRAPH 6. SPANISH COMPANIES' REASONS FOR NOT USING AI (% of total number of companies that have ever considered using AI technology)



Source: Compilation based on INE Survey on the use of ICT and e-commerce in companies (1st quarter 2024), October 2024.

followed by their use in the organisation of administrative and business management processes, as well as in the execution of production or service provision processes. However, in these two areas and elsewhere, micro-enterprises use AI less intensively than enterprises with 10 or more employees.

Finally, with a view to designing measures to promote the use of AI by the production sector, it is worth understanding why companies decide not to adopt these technologies, even after having considered their implementation (Graph 6).

More than three of every four Spanish companies have given up on using AI due to a lack of relevant expertise in the company.

Micro-enterprises are also reluctant to use AI for reasons of legal uncertainty due to lack of clarity regarding the legal consequences of its use, or due to the risk of breaching data protection and privacy regulations. For other companies, legal uncertainty is also the second most important reason for not adopting this technology, followed by difficulties in obtaining the necessary data or ensuring their quality.

Finally, it is also worth noting that less than 10 per cent of enterprises (with 10 or more employees) have not used AI because they do not find it useful; in case of micro-enterprises, this figure increases to 16.5 per cent.

Digital divides and AI

Despite the progress made in recent years, the persistence of digital divides in Spain, which is the subject of ongoing analysis by this Council, may pose an additional challenge both for AI integration in Spanish production structures and its social appropriation.

Digital transformation in general, and AI developments in particular, require high-capacity networks, such as fibre-optics or 5G, cloud storage and data centres, and high processing power. For example, activities that require real-time processing, such as those related to digital health, Industry 4.0, connected mobility, or cybersecurity, rely on these infrastructures.

Spain's progress in digital connectivity[56] undoubtedly facilitates the integration of these new technologies, however, it is still limited in some rural areas or in areas with low population densities, which may constitute a barrier to the development of AI and condition its use, especially in the primary sector and in the small and medium-sized enterprises that make up the majority of the production sector in rural areas. As a matter of fact, in addition to the gap between rural and urban areas, there are also differences in digital uses for reasons of business size or socio-economic reasons.

Once again, the Economic and Social Council (ESC) wishes to insist on the need to intensify deployment in rural areas in order to guarantee high-speed telecommunications networks as a way of avoiding, once again, a digital divide between Spanish territories in terms of both infrastructure and future advanced uses such as AI, thereby contributing to territorial cohesion.

In terms of the business gap, small and medium-sized enterprises generally use AI solutions less intensively, as discussed above. Their difficulties in accessing finance, the lack of qualified staff for advanced technologies, or a less developed digital culture are the main factors explaining this difference with large companies. This limits in-

56 European Commission, Spain *2024 Digital Decade Country Report*.

vestment in technological infrastructure and hinders the uptake of AI-based solutions among small businesses.

Moreover, from a dynamic perspective, this gap may widen, as companies that adopt and implement AI solutions early on generally tend to improve their efficiency and increase their competitiveness, generating a greater capacity to further reinvest in new technologies, which, as noted above, is inherently necessary in the new Industrial Revolution. In this way, they generate experience and innovative capacity that feeds back positively into their advantageous position by widening the business gap.

To address this problem, the new Spanish Artificial Intelligence Strategy 2024 has dedicated its lever number 6 to aiding in AI expansion in the private sector, especially in small and medium enterprises, and does so with the aim of "capitalising on productivity gains in all sectors and generating new business opportunities through value-added services where AI provides differential value". To this end, three initiatives are considered: the first is dedicated to AI incorporation in SME processes, which, amongst other measures, introduces the *Consulting Kit,* following the *Digital Kit* model, in order to advise SMEs on the adoption of AI solutions and is supported by the *Acelera pyme* platform. The second initiative is aimed at developing the AI entrepreneurship ecosystem, to facilitate access to funding for start-ups, or to consolidate the development of highly innovative technology-based companies (scale-ups) developing new AI solutions. And the third and last initiative is to establish a secure infrastructure so that the business sector can develop and test new products and services by creating specific and specialised models in various sectors or activities.

However, beyond specific initiatives, this Council believes that small companies should also develop a corporate culture that encourages technological change and they should participate in ecosystems that ensure inter-company cooperation strategies. It is important to insist on the need for greater awareness, literacy and promotion of digitalisation among small businesses in Spain so they may understand the true dimensions of this process and the implications of new technologies for the future of their businesses.

Cybersecurity challenges and opportunities

According to the latest figures from the Ministry of the Interior on crime in Spain, IT fraud amounted to 414,133 offences in 2024, 3.1 per cent less than in 2023. However, the long-term trend indicates the growing importance of these crimes. In its latest available report on cybercrime in Spain, the Ministry of the Interior indicated that, between 2019 and 2023, cybercrime grew by 116 percent, from 218,302 to 472,125 registered cases, which shows the growing exposure of citizens and companies to this type of threat.

In 2023, nine out of ten crimes were IT fraud – the input, alteration or deletion of computer data, or interference with computer systems for profit – with a growth of

FIGURE 4. CYBERCRIME, KNOWN FACTS BY CRIMINAL CATEGORY

Category	**2019**	**2020**	**2021**	**2022**	**2023**
Unlawful access and interception	4.004	4.653	5.342	5.578	7.367
Threats and coercion	12.782	14.066	17.319	15.982	17.472
Slander	1.422	1.550	1.426	1.191	1.174
Against industrial/intellectual property	197	125	137	114	64
Sexual offences (*)	1.774	1.783	1.628	1.646	1.804
Computer forgery	4.275	6.289	10.476	12.569	15.137
Computer fraud	192.375	257.907	267.011	335.995	427.448
Data and system interference	1.473	1.590	2.138	1.662	1.659
Total known incidents	218.302	287.963	305.477	374.737	472.125

Source: Ministry of the Interior, *Informe sobre la cibercriminalidad en España, 2023*.

122.2 per cent in the last five years. IT counterfeiting also stands out, although with lower absolute figures, it has recorded the highest relative growth, with an increase of 254.1 per cent. Increases in illicit access and system interference, as well as sex crimes committed through digital means are also noteworthy, reflecting a growing diversification of cybercrime. Only crimes of libel or against industrial and intellectual property have fallen in the last five years.

The latest Economic and Social Council (ESC) Research Award addressed precisely this problem, and its executive summary noted that "digitalisation has transformed the economy and society, but these changes have led to an exponential increase in cybercrime. This problem is becoming increasingly evident as the threats are much more sophisticated due to the intensive and extensive use of emerging technologies. Cybercriminals exploit a wide range of digital tools to attack computers and systems, compromise sensitive data, and execute crimes more easily and cost-effectively. (...) This situation is complicated by the absence of a unified legal framework and the lack of international consensus on cybersecurity. This poor – or even non-existent – coordination can lead to relative impunity for cyber-attacks, increasing both the economic impact and erosion of trust in digital systems, undermining e-commerce. Moreover, this growing sophistication of cyber-attacks is not limited by size or business sector. Due to their interconnected nature, no company, organisation or individual is totally secure, not even the largest and/or those with sufficient financial and technological means.

Within this framework, Artificial Intelligence currently plays a key role in detecting and responding to cyber-attacks, thanks to its capacity for the predictive real-time analysis of large volumes of data, which allows it to identify anomalous behaviour and predict potential threats accordingly[57]. Additionally, AI can automate responses to cyber-attacks, enabling more agile and effective responses, thereby improving cyber resilience. However, AI also poses significant challenges, as its use by cybercriminals has led to increasingly sophisticated attacks, such as automated *phishing* [58] or the creation of *deepfakes*[59],, making it more difficult to detect.

All of this poses an economic/financial and technical challenge in terms of cybersecurity, as it requires, on one hand, continuous investment in advanced software solutions and infrastructures and, on the other hand, qualified personnel in this field, the latter being a major challenge for almost all economies, including that of Spain[60]. Indeed, human oversight is essential to ensure that AI usage in cybersecurity is balanced and ethical.

R&D&I and AI, a two-way relationship

In Spain, efforts have concentrated on promoting R&D for AI development. In 2019, the Spanish Ministry of Science, Innovation and Universities presented the Spanish Strategy for R&D&I in Artificial Intelligence, which, together with the 2018 European "Coordinated AI Plan", would constitute the seed of the National Artificial Intelligence Strategy and concentrated efforts on promoting R&D&I in AI in technologies related to personalised medicine, tourism services, cybersecurity, and the development of an interoperable and digital public administration.

From 2021, within the framework of the Recovery Plan, the R&D Missions in Artificial Intelligence programme was launched as part of the Digital Spain 2025 agenda of the National Digital Intelligence Strategy, with the aim of financing, until the end of 2024, collaborative projects bringing together large companies, SMEs and knowledge institutions, with a focus on low and medium maturity technologies[61]. Projects were assessed according to criteria such as reducing social gaps, ecological transition or the inclusion of SMEs, and should be framed within one of five strategic sectors: carbon-neutral agriculture, preventive health, environmental recovery, employment adapted to the future of work, and enewable energies. Furthermore, R&D investment related to the development of infrastructures such as data centres or supercomputing, as well as

57 Galián L. (2024): "Impacto de la IA en la ciberseguridad. Reforzar la resiliencia digital", *Revista Bit*, n.º 232, pp:14-18. Colegio Oficial de Ingenieros de Telecomunicación.

58 Automated *phishing* with AI enables the generation and distribution of large volumes of fraudulent messages, tailoring the content to each victim using natural language processing or profiling techniques.

59 A process that uses advanced AI techniques, especially neural networks, to generate fake but realistic audiovisual content.

60 It is worth noting that cybersecurity has been included as a priority objective in the Industrial and Technological Plan for Security and Defence presented in 2025. Thus, 31 percent of the funds are dedicated to developing and acquiring new telecommunications and cybersecurity technologies.

61 In April 2025, the Council of Ministers approved a call for research projects in Artificial Intelligence, managed by the State Research Agency and with an initial budget of 31 million euros, extendable to 36 million, no longer linked to the PRTR. This initiative, part of the State Research Plan 2024-2027, seeks to boost specialised AI talent and respond to scientific, technical, social and economic challenges.

FIGURE 5. R&D&I CHALLENGES POSED BY AI

1. Regarding **talent and training**, it is pointed out that an increasing use of AI in research may generate dependence, affecting skills such as scientific intuition or critical thinking, when these are necessary to generate scientific disruptions. Moreover, the use of AI may detract from the relationship between senior and junior researchers (including PhD students), which has been essential for the transfer of knowledge or for the critical appraisal of results. It is therefore essential that education is redesigned to integrate AI without losing the essential skills of researchers.
2. It may affect **scientific publishing**, as a massive use of AI to write papers may jeopardise the authenticity and quality of scientific output, and call into question the current system of publication-based evaluation. However, AI may bring objectivity to the system by reporting negative/failed results, overcoming the current bias towards publishing positive results, which will help future research.
3. It encourages **interdisciplinary research** by facilitating collaboration between researchers from different subjects via the analysis of complex/different data from other disciplines, revealing possible unexpected connections. However, AI could also replace direct dialogue between researchers, which is worrying and ultimately impoverishing, as for the time being, the human exchange of ideas is essential.
4. It challenges the current **scientific bureaucracy** and funding mechanisms, as the speed that AI brings to research is obstructed by slow and lengthy procedures for obtaining public funding.
5. Access to and adoption of Artificial Intelligence is marked by **inequalities** that especially affect stakeholders with fewer resources, which may increase existing innovation gaps. It is therefore essential to democratise access, promote training and develop shared infrastructures and ecosystems.
6. Within organisations, AI can bring about a change in how R&D&I is conducted as it facilitates communication and integration between different departments, which may require changes in their structure, functioning and, obviously, in their **culture of innovation**. In any case, automation must be balanced with the preservation of multidisciplinary teams, to not lose the diversity of perspectives that leads to the most disruptive innovations.
7. AI raises new **ethical and regulatory issues**. The absence of clear regulatory frameworks can lead to problems of bias in AI models, hence it is essential to establish rules that ensure fairness and transparency in order to understand and validate AI results, while maintaining scientific integrity. Additionally, questions of authorship and intellectual property may arise when AI significantly influences scientific discoveries.
8. Does it mean **the end of the Knowledge Economy**? Knowledge is currently a limited asset, but if AI makes it simpler and cheaper to generate and apply research, it could become a commodity, similar to the internet. Moreover, while AI would democratise discoveries and inventions, it reduces the competitive advantage of those who promote them, thus also reducing the incentive to protect them through industrial property rights.

Source: Authors' own based on COTEC, *Conclusions of the Workshop on the Impact of AI in R&D&I Processes,* 2025.

boosting human capital in this field, generate a technological ecosystem conducive to AI development.

But, conversely, AI itself is a very powerful tool for research and is clearly revolutionising R&D processes. In fact, AI was also in the spotlight at the 2024 Nobel Prizes, when the Physics and Chemistry prizes were awarded to scientists whose work focused on the development and application of AI tools[62].

Indeed, AI is playing an increasingly important role in R&D processes, due to the multiple advantages of its use in different stages of these procedures. These include: the ability to analyse large volumes of data, the automated formulation of hypotheses, the modelling of complex phenomena, the optimisation of experimental designs or the validation of results. This not only speeds up the pace of scientific discoveries but also provides substantive support for research work. In disciplines such as engineering, biotechnology and pharmacology, AI has demonstrated its potential to significantly reduce research timescales, as proven by the generation of new materials in weeks, compared to the years previously required[63].

AI applications in R&D&I merit reflection both for the opportunities they offer and for the risks and challenges they entail. In February 2025, the COTEC Foundation[64] held a trans-disciplinary workshop to explore the role of Artificial Intelligence in research, development and innovation. Specifically, COTEC has identified eight challenges posed by generative AI in scientific research processes that question conventional research processes and force a rethink of the governance of research institutions and companies (Figure 5).

5. The role of economic policies in the face of technological challenges

The opportunities and challenges posed by technological change, as the Economic and Social Council (ESC) has repeatedly pointed out, must be tackled from a multidimensional approach, in order to achieve a balance between favouring and promoting accelerated technological development and at the same time ensuring that its benefits reach all of society without compromising fundamental rights, minimising undesired consequences on economic and social balances and ensuring that no one is “left behind”, neither citizens nor sectors nor companies nor territories.

In this sense, an economic policy in favour of AI should be seen as a comprehensive strategy that, on the basis of clear and transparent principles and rules of the game,

62 Geoffrey Hinton and John Hopfield received the Nobel Prize in Physics for creating machine learning models based on neural networks, laying the technical foundations of modern AI. The Nobel Prize in Chemistry was shared by David Baker, for the computational design of new proteins, and Demis Hassabis and John M. Jumper for creating AlphaFold2, a tool that decodes microscopic protein structures - key, for example, to understanding rare diseases or developing new drugs.

63 Stanford Institute for Human-Centered Artificial Intelligence. *The AI Index Report: Measuring Trends about AI*, 2024.

64 COTEC, *Conclusiones del Taller sobre el impacto de la IA en los procesos de I+D+i*, 2025.

seeks to maximise the benefits for society and limit the risks and negative effects of technological change[65].

For this, it is essential to have an AI governance framework that, based on the principles of equity, transparency and accountability, aims to achieve reliable, inclusive, sustainable and enriching AI[66]. But it also implies addressing clear regulations that provide certainty and a digital ecosystem that stimulates innovation and favours scientific research, with instruments that facilitate the AI adoption by citizens and businesses, especially SMEs, both in terms of physical capabilities and human and organisational skills.

The EU's approach to Artificial Intelligence, as noted above, has been focused from the very beginning on boosting research and industrial capacity, while ensuring security and fundamental rights. Excellence and trust are the elements underpinning this approach so that the benefits of AI may be enjoyed safely and securely. It is within this context that the regulatory and strategic initiatives to be deployed in Spain in the field of Artificial Intelligence should be placed.

Establishing an AI governance framework

The rapid evolution of AI technologies makes it necessary to implement policies that proactively consider and manage the technological changes driven by AI and its future developments. But this requires a prior governance framework in which policy makers, social stakeholders, businesses, the research community and other AI actors commit to common principles and concrete actions aimed at capturing the benefits of AI and managing its risks, but also at strengthening capacities to anticipate and shape future AI developments.

For over a decade now, attention has been paid to the overall governance of the digitalisation process in order to ensure that the transition results in a positive balance. Within this context, AI governance itself has become especially relevant because of its ethical, security and trust-based implications. As early as 2019, the OECD's "Declaration of AI Principles" noted that technology should respect human rights and democratic values and the principle of responsibility in its development should be linked to safety, security and privacy. Since then, not only international and European institutions, but also many national ones have reached a consensus on establishing a governance framework to ensure the protection of individuals and their fundamental rights, to agree upon ethical values in their use, and to build trust while promoting innovation.

In this context, the European Commission has been a pioneer with the creation of the High Level Expert Group on Artificial Intelligence in 2019, the adoption of the "Ethical Guidelines for Trustworthy AI" and the publication of the "White Paper on

65 OECD (2024), *Assessing potential future AI risks, benefits and policy imperatives*, Artificial Intelligence Papers.

66 Wirjo, A. et al (2022), *Artificial Intelligence in Economic Performance*, Policy Brief Asia-Pacific Economic Cooperation, no 52, November.

Artificial Intelligence" which set out the European approach towards AI development, based on two pillars, technical excellence and trust in AI. A more recent milestone, in 2024, is the regulation of AI use, which follows a risk-based approach and establishes prohibited uses as a consequence.

Having an AI governance framework requires greater coordination between supranational bodies and countries, but also at other levels (regional and local), fostering public-private collaboration and promoting partnerships with experts. The goal is to promote safe, reliable and adaptable AI that may be adjusted to the rapid advances that are taking place, based on ethical principles jointly and globally agreed by supranational bodies, governments and companies. This is stated in the report "Governing AI for Humanity" adopted in 2024 by the UN, which proposed the creation of an international group of scientists, international forums on governance standards and policies, a network of AI capacity building centres, a global data framework, and a fund to bridge any gaps that may arise.

On the other hand, AI can also contribute to the formulation and implementation of public policies themselves[67]. The possibility of relying on AI to conduct strategic foresight exercises with larger volumes of information makes it possible to address complex problems, assess the feasibility and effectiveness of different policy options and thus guide decision-making. It can also contribute to public policy monitoring and evaluation by enabling the processing of mass outcome data. This results in the improved efficiency and quality of public services.

Ensuring a regulatory framework that provides safety and security

AI development requires a clear and transparent regulatory framework that establishes the same rules of the game for all actors involved in this process of technological change. Regulations must strike a balance between ensuring protection and legal certainty for citizens and businesses without stifling creativity and business competitiveness and broad acceptance of AI[68]. The regulatory framework should provide a favourable investment climate for innovation with the necessary flexibility to accommodate rapid technological developments in this area.

Regulatory developments, in this sense, should be based on the European AI Act approved in 2024, which, aware of the disruption that this new technology represents, has put forward a harmonised regulatory framework at European level and of a cross-sectoral nature in the field of Artificial Intelligence. It extends beyond specific regulations on key issues that affect the development of AI, such as data privacy, cybersecu-

67 Wirjo, A. et al (2022), *Artificial Intelligence in …;* op.cit.

68 Simons, W. et al (2024), *Artificial Intelligence:. Economic Impact, opportunities, challenges, Implications for policy*. European Commission Discussion Paper 210, July.

rity, digital information exchange, or competition rules to avoid market concentration dynamics.

In any case, there are regulatory gaps related to AI, especially with regard to transparency, accountability, non-discrimination, unethical control practices, data collection and use, and its implications, for example, on economic security. Or in relation to intellectual property rights that underpin the outcome of AI applications with far-reaching implications. Indeed, there is legal uncertainty over issues related to the copyright of both the contents of AI applications and the returns, which may reduce incentives for further investment in their development and content generation, penalising innovative activity. Hence, the need to adapt this regulatory framework to the rapid developments in this field.

To have a digital ecosystem that favours AI development

AI development requires the existence of a digital ecosystem where innovation emerges with the technological change itself, since AI has an enormous potential to generate new innovations. Therefore, having an AI ecosystem is essential for any region in order to continue to innovate and promote the creation of opportunities.

As pointed out in a previous section, AI offers new opportunities for the production sector due to its own breakthrough, but also due to the improvements it brings to other technological developments. Moreover, AI can also accelerate scientific research and generate advanced solutions in numerous fields such as health, climate change, industrial development and others. Hence the need to strengthen essential infrastructures and facilitate access to them, to invest in new technological developments, and to adopt advanced technologies in order to identify and correct gaps in developments.

All of this makes it necessary to articulate tools that give a greater boost to R&D and promote innovation, reinforcing capacities in order to prevent the Spanish economy from falling behind in the most innovative technologies with the greatest future potential. The latest focus is on boosting developments in quantum computing, cloud infrastructures, AI language models and the need for talent.

Moreover, in order to extract the full potential of AI, further investment must be encouraged, especially in intangible assets, where there are serious gaps in both R&D&I and knowledge. As mentioned above, low investment in intangibles leads to uneven adoption and use of digital advances in the production sector, explaining part of the lower productivity growth. In this respect, the Economic and Social Council (CES) has frequently pointed out the importance of scientific and technological progress and, in short, that greater and more efficient investment in R&D&I are key to increasing factor productivity and guaranteeing the sustainable medium and long term growth, while maintaining a balance between the economic, social and environmental dimensions.

Moreover, as noted previously, this digital ecosystem must guarantee data privacy and security. Cybersecurity strategies must be deployed as, due to high interconnectedness, no company, organisation or individual is totally secure, not even the largest and/or most technologically equipped. Its goal should be to boost confidence in digital usage and to prevent security breaches of not only sensitive individualised information but also the predictive models designed on the basis of this information.

Furthermore, quality data is key to AI adoption and usage, as data is the critical input for this technology. Hence, a digital ecosystem must not only provide for data security and privacy, but also for data storage, management and processing. Within this area, there is room for the creation of massive data centres for storage and supercomputing for processing.

Ensuring competition rules to minimise market concentration tendencies

The emergence of digital technologies has led to increasing complexity in the industrial and economic foundations on which antitrust law has been built. AI further exacerbates this complexity as larger, more resource-intensive companies are more likely to adopt, deploy and even develop this technology[69]. Thus, the presence of economies of scope in this area gives participating companies strong competitive advantages over the rest of the producers.

In fact, there are likely to be positive feedback loops between the use of AI and company size: investments in AI are concentrated among larger companies, which logically have more means to develop and access AI, and obtain higher returns in the form of sales and market share[70].

Evidence shows that it is difficult to counteract the market concentration of large digital players in order to limit non-competitive behaviour, which is difficult to regulate or control[71]. These concerns are part of the discussion within the framework of antitrust policies. Hence, digital ecosystems and the data economy require the reinforcement, revision and adaptation of the concepts, doctrines and methodologies of antitrust law, so that AI dissemination and access takes place on competitive terms with an equitable distribution of its returns for the production sector as a whole.

Boosting AI adoption and usage

The insecurity and sense of a lack of protection that is often associated with AI usage makes it necessary to put in place mechanisms to generate confidence and encourage its adoption by citizens and companies, especially SMEs. The goal should be to improve service delivery to citizens and serve as a catalyst for change in the private sector.

69 Simons, W. et al (2024), *Artificial Intelligence:. Economic Impact, ...*; op. cit.

70 Just 100 companies, mostly in the US and China, are behind 40 percent of the world's private investment in Artificial Intelligence research and development. See UNCTAD (2025), *Technology and Innovation Report 2025:. Inclusive Artificial Intelligence for Development*.

71 See CES (2021), *Informe sobre La digitalización ...;* op. cit.

In this regard, current barriers to the adoption and deployment of AI need to be overcome. Public policies must address different aspects, from facilitating access to establishing essential infrastructures such as computational resources and data (data sharing initiatives and promoting access to protected data for training, cloud infrastructure, computing power or AI engineering talent), but also to bank and non-bank funding to support investments in AI capabilities. AI deployment is notably costly for SMEs, especially when it comes to data processing, storage and integration into software systems.

At the business level, it is necessary to design a support framework for the complete production sector with special attention to SMEs and micro-SMEs, including advisory measures with one-stop services and user-centred solutions, aid and incentives to boost IT and computing skills, and data infrastructures to enable the widespread incorporation of AI, worker training in advanced digital skills at both managerial and organisational levels, in order to harness the potential of AI while counteracting the negative effects of its deployment, and attracting digital talent in advanced technologies.

Specific actions should also be promoted in dynamic sectors and collaborative partnerships encouraged, in addition to the creation of platforms for data access and exchange, and technology transfer. The aim is to enable disruptive innovation and its adoption, including in SMEs, for example by establishing public sector "regulatory test environments" that are available to SMEs and startups in order to develop and train innovative AI.

Beyond these measures at the national level, there is a need for pan-European collaboration in order to overcome the current fragmentation of the EU digital market and to support the creation of the large and integrated datasets needed to train AI models.

Citizens must also be able to access it, so they have the necessary skills to exploit the potential of these new technologies and, especially that of AI. In this regard, measures to boost AI talent within the population may be addressed in an inclusive manner, as outlined in more detail in the section on this issue in the following chapters.

In conclusion

The recent emergence of disruptive technologies with great potential, especially Artificial Intelligence, makes it necessary to address a comprehensive strategy that encompasses the development, deployment and use by society as a whole. This includes all relevant actors, public and private sectors, experts and citizens, in order to extract the full potential offered by these technologies and to minimise their negative effects. This implies the involvement of economic and social stakeholders, as the challenges arising in its economic, employment, environmental and social aspects make it necessary to reach a broad social consensus on the uses of Artificial Intelligence, its limits and how it interacts between people and developments, with the goal of making AI a beneficial instrument to generate stable, sustainable and inclusive development in the medium term.

FIGURE 6. ECONOMIC IMPACTS OF TECHNOLOGICAL CHANGE

A FOURTH INDUSTRIAL REVOLUTION ACCELERATED BY ARTIFICIAL INTELLIGENCE

The economy, work and society have been profoundly changed by major technological disruptions that have generated new paradigms, paving the way for different industrial revolutions.
We are currently immersed in the fourth industrial revolution, consisting of fully consolidated technological advances such as hyperconnectivity, a high penetration of the Internet of Things, the application of artificial intelligence systems or advanced big data analysis.

DISTINGUISHING ELEMENTS OF THE 4TH INDUSTRIAL REVOLUTION

Global, multi-sectoral and interconnected scope:

It is not limited to a specific sector, but transforms multiple areas of human life beyond the world of production.

Unprecedented speeds:

It is unfolding at a dizzying pace, much faster than previous revolutions, thanks to technologies such as artificial intelligence, automation, and quantum computing.
Widespread impact on employment. It affects manual tasks as well as intellectual and creative work, requiring constant adaptation, continuous training, and the acquisition of new skills.

Prominence of data:

It is driven by access to and analysis of big data, which creates new challenges related to privacy, ethics and information security.

More complex ethical and social challenges:

It rises the debates on the balance between technological progress and individual rights, especially with regard to consent and personal data protection.

New geopolitical context:

In contrast to previous stages which were marked by global expansion, the current revolution is taking place in an environment of revised globalisation, with a rise of protectionism and the search for strategic autonomy in the wake of events such as the pandemic.

AI AS A MAJOR DISRUPTIVE ELEMENT

Within the fourth industrial revolution, artificial intelligence represents the convergence of advances in computing, bigdata, machine learning and algorithms.
It endows machines with the ability to perform human intelligence tasks, such as reasoning, learning or creativity, by means of algorithms and models based on mathematical, statistical, logical, computer and linguistic knowledge, imitating or even improving human cognitive functions.
Currently, the generative version (GenAI) has attracted the most interest.

Potential and challenges of GenAI

Potential:

- Creates quality and diverse content
- Generates synthetic tabular data
- Complements/replaces human labour
- Improves user experience
- Democratises information
- Promotes R&D

Challenges:

- Generates false content
- Creates/amplifies biases
- Reduces/limits creativity
- Causes/exacerbates conflicts, dilemmas or ethical, legal and social problems
- Hinders/impedes control, oversight or regulation

Source: COTEC.

MACROECONOMIC IMPACT OF AI

Existing consensus:

AI has transformative potential, but unpredictable macroeconomic impacts.

Empirical evidence:

It expects the impact of AI to be limited as it is at an early stage of adoption. Macro-level estimates show clear impacts, but with a very open range. Therefore, the academic literature has opted to estimate the micro-level impact on specific tasks and occupations and, from there, to infer aggregate effects for the economy as a whole. In any case, advances in AI must be disseminated throughout the economy for productivity gains to materialise. This takes time, as they must be adopted and deployed by all firms, including SMEs, and some may be slow to adopt these new advanced technologies or lack the skills to make them profitable.

Limitations:

To what extent, how and when the resulting efficiency gains and potential effects on productivity and economic growth will materialise is difficult to judge and will depend on the speed of progress, the diversity and development of applications, and their widespread deployment, and even whether they will accelerate further or stagnate. The lack of indicators to measure the resulting cost savings makes it difficult to analyse the impact.

Other impacts:

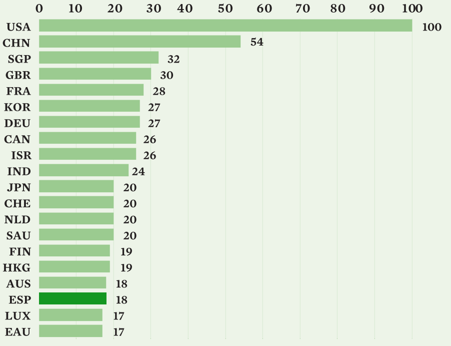
Other macroeconomic impacts of AI on employment and the labour market, as well as social and environmentalimpacts, need to be considered as a whole when assessing its contribution beyond productivity gains and growth.

Need for increased research efforts:

To overcome the imbalance between the scale and speed of the emergence and deployment of these disruptive technologies, and the limited knowledge of their consequences.

FIGURE 6. ECONOMIC IMPACTS OF TECHNOLOGICAL CHANGE (*continuation*)

POSITIONING IN AI INNOVATION AND INVESTMENT



Source: Tortoise, Global AI Index, 19 September 2024

THE IMF'S AI PREPAREDNESS INDEX, 2023

It measures preparedness based on indicators related to: digital infrastructure, innovation and economic integration, human capital and the labour market, regulation and ethics.

Singapore, Denmark and the United States top the index

The EU is at 66% of its optimal prepared-ness level

Denmark, the Netherlands, Estonia, Finland and Germany exceed 75%

Spain is 65% of the way to optimal readiness

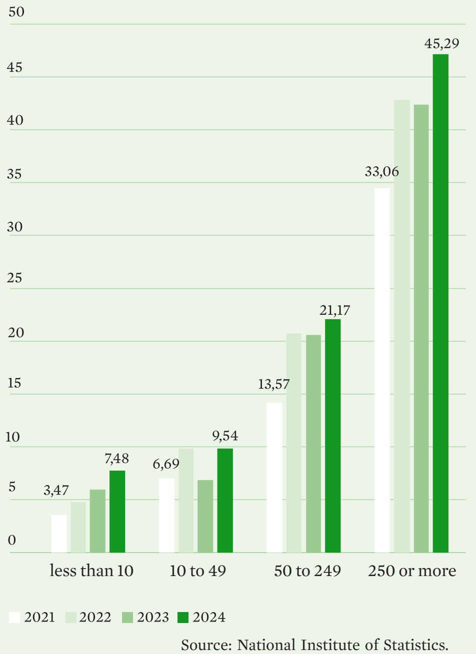
By category, Spain ranks among advanced economies in terms of digital infrastructure and innovation and economic integration, however it ranks lower in terms of human capital, labour market and regulation and ethics.

Artificial Intelligence, a key driver of productive activity

Deployment within the production fabric: situation and challenges

Situation

EVOLUTION OF AI USE IN SPAIN BY COMPANY SIZE



Source: National Institute of Statistics.

- **Significant growth** in AI adoption by Spanish enterprises.
- Significant variation in adoption **by size and sector of activity.**
- **Service companies** make the greatest use of AI in their activity, at 15.6 per cent.
- **Large industrial companies** are the most intensive users of AI, at 48 per cent.
- The AI tool most used by Spanish companies is **written language analysis.**
- The main application of AI is in **marketing and sales.**
- More than three out of four Spanish companies have given up on using AI due to a **lack of** relevant **expertise** in the company.

FIGURE 6. ECONOMIC IMPACTS OF TECHNOLOGICAL CHANGE (*continuation*)

Deployment within the production fabric: situation and challenges	**Gaps**	• Despite the progress made, **digital divides persist** in Spain, which may limit the development of AI. • Connectivity remains limited in certain rural areas or in areas of low population density. • **Small and medium-sized enterprises** generally use AI solutions less intensively. • There is a need for greater **awareness, literacy and promotion** of the digitalisation of small businesses.
	Cybersecurity	• **Increasing exposure** of citizens and businesses to such threats. • AI currently plays a **key role** in detecting and responding to cyber-attacks. • AI also poses challenges since its use by cyber criminals has led to **increasingly sophisticated** attacks. • The development of AI poses an **economic-financial and technical challenge** in terms of cybersecurity • **Human oversight** is essential to ensuring a use of AI in cybersecurity balanced and ethical.
	R&D&I	• In Spain, efforts have been concentrated on promoting **R&D** for the development of AI. • AI is a very powerful tool and it is **revolutionising R&D processes** • **Advantages**: the ability to analyse large volumes of data, automated formulation of hypotheses, modelling complex phenomena, optimisation of experimental designs, or validation of results • **Proven potential** in disciplines such as engineering, biotechnology and pharmacology.
Economic policy in favour of AI	Conceived as a **comprehensive strategy** which, on the basis of **clear and transparent principles and rules of the game**, should aim to achieve a balance between favouring and promoting an accelerated **technological development** and ensuring that its benefits reach all **society** without compromising **fundamental rights**, minimising unintended consequences on economic and social balances and ensuring that **no one is "left behind".**	
	Key elements	• Having an **AI governance framework** that, based on the principles of equity, transparency and accountability, aims to achieve reliable, inclusive, sustainable and enriching AI. • Adopting **clear regulations** that provide certainty • Fostering a **digital ecosystem** that encourages innovation and favours scientific research. • Promoting the **adoption of AI** by citizens and businesses, especially SMEs, both in terms of physical capabilities, and human resources and organisational skills.

CONCLUSION

The great challenge facing societies with regard to technological transformation is to ensure that technological transformation, mainly digitalisation, and related developments and innovations, such as AI, are geared towards human, social and environmental progress.

The recent emergence of disruptive technologies with great potential, especially AI, makes it necessary to address a comprehensive strategy that encompasses the development, deployment and use by society as a whole. This includes all relevant actors, public and private sectors, experts and citizens, in order to extract the full potential offered by these technologies and to minimise their negative effects.

This implies the involvement of economic and social stakeholders, as the challenges arising in its economic, employment, environmental and social aspects make it necessary to reach a broad social consensus on the uses of AI, its limits and how it interacts between people and developments, with the goal of making AI a beneficial instrument to generate stable, sustainable and inclusive development in the medium term.

Source: Authors' own.

LABOUR IMPACTS OF TECHNOLOGICAL CHANGE

1. Impact on employment

The impact of technological change on employment may be quantitative (net creation or loss of job positions), qualitative, or a combination of both. Employment may also be affected in terms of changing profiles within jobs and occupations, and their related skill requirements. These same factors may also affect changes in pay and in the range of aspects that typically define job quality.

The above may be grouped into three strands, which will be summarised below and for which some international and European-level results will be provided. Subsequently, it conducts an in-depth analysis for Spain, but only in terms of employment volumes, wage developments and the characteristics of the people "most exposed" to technological change. The other aspects are closely related, on one hand, to employment and training policies and, on the other hand, to the field of labour relations, and require their own specific developments, also geared towards the analysis of policies and instruments required to govern these changes.

1.1. OVERVIEW

Impact on the volume of employment

The impact of technology on employment is materialised through three main channels:

- The first channel has to do with productivity gains from innovations and capital growth.
- Another channel is associated with the displacement of certain workers performing certain production tasks, which become redundant due to new technologies.
- Thirdly, technological innovations generate new jobs that require supplementary skills and professional qualifications.

Net positive impact of technological change in the long term

In general, it is estimated that technological innovations until now have maintained (and even increased) employment levels. Specifically, the displacement effect has traditionally been outweighed by productivity growth and the emergence of new jobs. At the aggregate level, technological change has not prevented employment rates from rising, without affecting the unemployment rate in recent decades. In fact, the demand for labour increased strongly in line with the increase in supply.

Growing concern regarding automation and attempts to measure its impact

However, in the last decade there has been a growing concern about automation[72] fuelled by the perception that the change is not only faster but also more broadly based than in the past, which means that more jobs may be automated than previously thought. Several studies have attempted to predict what proportion of jobs may be automated as a result of the penetration of new workplace technologies. Estimates from early studies were built using expert assessment of the likelihood that different occupations could be automated. This occupationally focused approach yields high percentages of workers exposed to a high risk of automation (Figure 7).

Critics of these estimates argue that the occupations as a whole are unlikely to be automated. While the adoption of technology has led to the disappearance or creation of jobs, it typically replaces specific tasks within an occupation or a position, transforming but not eliminating the position itself. In other words, automation technologies would displace, replace or transform tasks in different positions, but not the positions themselves. Thus, new studies have followed a different approach that also takes into account the tasks that are part of the work activity in each of the occupations. From this perspective, the estimated probability and exposure are usually much lower and incorporate the possibility that jobs may be transformed rather than disappear, which significantly changes the concept of "exposure" from a risk of job loss (Figure II-29).

Neutral impact of automation technologies prior to generative AI

So far, there is little evidence of a significant fall in overall employment in labour markets as a result of automation implemented within this period, even where a higher proportion of jobs have been estimated to be at risk (Figure 8). Similarly, the few studies that have already addressed the impact of AI on aggregate employment have found little to no effect on employment (Figure 8). The low overall adoption of AI; low productivity gains (see Chapter I); the fact that advances in AI and exposure to AI do not necessarily imply automation; and the creation of new tasks and jobs driven by advances in AI are often highlighted among the reasons for not finding significant impacts on employment to date.

72 Automation may be understood as the application of technology to achieve results with minimal human intervention. Automation technologies therefore encompass a broad set of technologies, including digital –which include both conventional and AI-driven software that may or may not be generative AI– and mechanical systems, among others.

FIGURE 7. SUMMARY OF AUTOMATION RISKS. SELECTED STUDIES

Publication	Level of analysis	Approach	Results
Frey and Osborne (2013, 2017)	Country: USA	Occupations	Estimates that almost half of all jobs (47 per cent) are at risk of being replaced by computers or algorithms in the coming years.
Bowles (2014)	Multi-country: EU	Occupations	Estimates an average automation risk of 54% for the EU as a whole and 55% for Spain.
Josten and Lordan (2020)	EU	Occupations	They estimate that 47.4% of jobs will be automatable within a decade (of which 35.2% are fully automatable).
Crowley et al., (2021)	European regions	Occupations	Among European regions, there is significant variation in exposure to the likelihood of automation. The regions most at risk are in Eastern Europe, the Mediterranean area and Western regions.
Yamashita and Cummins (2021)	Country: USA	Occupations	48 per cent of jobs at risk
Gallego (2017)	20 European countries	Occupations	Estimates average risk in Spain at 52%, the highest risk in Lithuania, Czech Republic and Portugal (46%) and the lowest risk in Finland, Norway and Switzerland (46%).
Domenech et al. 2018	Spain	Occupations	Estimates a high-risk employment rate for Spain of 36% for the average of the period 2011-2016.
Pouliakas (2018)	Multi-country: EU	Tasks	It estimates a high risk of substitution of 13.9% of employment for the EU as a whole.
Arntz et al., (2016)	21 OECD countries	Tasks	Estimates that 9% of jobs are at high risk of automation in 21 OECD countries as a whole (12% in Spain).
Nedelkoska and Quintini (2018)	32 OECD countries	Tasks	Estimates that 14% of jobs are at high risk of automation in 21 OECD countries as a whole (22% in Spain).
Manyika (2017)	Multi-country (global)	Tasks	Estimates that 49% of global labour activities can be automated (48% in Spain).
Foster-McGregor et al. (2021)	Multi-country: EU	Tasks	Estimates that between 47 and 64 per cent of jobs can be automated.
McGuinness et al. (2021)	Europe	Tasks	Estimate the percentage of workers affected by technological change: highest rates in Estonia (28%), Slovenia (25%), the Czech Republic (24%), Portugal (21%) and Ireland (21%). Lowest rates (<7%) in Bulgaria, Malta and Luxembourg.

Source: Authors' own.

FIGURE 8. SUMMARY OF NET IMPACT OF TECHNOLOGY ON THE VOLUME OF EMPLOYMENT. SELECTED STUDIES

Publication	Level of analysis	Technology type	Net impact
Autor and Salomons (2018)	Country	Automation technologies	Positive
Dekle (2020)	Country	Automation technologies	Positive
Sahin (2020).	Country	Automation technologies	Positive
Fu et al. (2021)	Country	Automation technologies	?
Acemoglu et al. (2020b)	Industry	Automation technologies	Positive
Aubert-Tarby et al. (2018)	Industry	Automation technologies	Positive
Klenert et al. (2020)	Industry	Automation technologies	Positive
Graetz and Michaels (2018)	Industry	Automation technologies	Neutral
Kromann et al. (2020)	Industry	Automation technologies	Neutral
Krzywdzinski (2021)	Industry	Automation technologies	Neutral
Acemoglu et al. (2020b)	Industry	Industrial robots and software	Negative
Borjas and Freeman (2019)	Industry	Industrial robots and software	Negative
Compagnucci et al. (2019)	Industry	Industrial robots and software	Negative
Webb (2019)	Industry	Industrial robots and software	Negative
Fu et al. (2021)	Country	Industrial robots	Positive
Carbonero et al. (2018)	Country	Industrial robots	Negative (especially for developing countries)
Focacci (2021)	Country	Industrial robots	Neutral
Leigh et al. (2020)	Regional	Industrial robots	Positive
Sequeira et al. (2021)	Regional	Industrial robots	Positive
Acemoglu and Restrepo (2020)	Regional	Industrial robots	Negative

Publication	Level of analysis	Technology type	Net impact
Aghion et al. (2020)	Regional	Industrial robots	Negative
Koch et al. (2019)	Labour market	Industrial robots	Positive
Mann and Püttmann (2018)	Labour market	Industrial robots	Positive
Chiacchio et al. (2018)	Labour market	Industrial robots	Negative
Du and Wei (2021)	Labour market	Industrial robots	Negative
Faber (2020)	Labour market	Industrial robots	Negative
Caselli et al. (2021)	Labour market	Industrial robots	Neutral
Dauth et al. (2017, 2018)	Labour market	Industrial robots	Neutral
Dottori (2021)	Labour market	Industrial robots	Neutral
Anton et al. (2020)	Labour market	Industrial robots	Negative (1995-2005) and positive (2005-2015)
Mutascu (2021)	Country	Artificial Intelligence	?
Xie et al. (2021)	Regional (China)	Artificial Intelligence	Generates unemployment for low-skilled workers
Felten, Raj and Seamans (2019)	Regional (USA)	Artificial Intelligence	Neutral
Georgieff and Hyee (2021)	Regional	Artificial Intelligence	Positive (but not significant)
Acemoglu et al. 2022	Industry (USA)	Artificial Intelligence	Neutral
Fossen and Sorgner (2022)	Individual (USA)	Artificial Intelligence	AI exposure found to decrease the likelihood of workers leaving jobs
Albanesi et al (2023)	European countries	Artificial Intelligence	Positive effect on employment rates

Source: Authors' own.

Increased reach and impact with the development of generative AI

However, recent developments have contributed to the wider use of AI technologies, leading to the emergence of generative Artificial Intelligence (Generative AI). The wider reach and ease of access of generative AI technologies suggest that they will have a more widespread impact on the labour market than previous waves of AI. According to OECD estimates, about a quarter of employment is exposed to generative AI (Graph 7), exposure which, according to the OECD, means that 20 per cent (or more) of their tasks could be performed at least 50 per cent faster with the help of generative AI, but only 1 per cent are considered highly exposed[73]. However, as generative AI technologies become embedded in the workplace, up to 70 per cent of workers could be exposed to generative AI soon, 39 per cent of whom consider themselves highly exposed to changes in the workplace.

It should be stressed that these exposure estimates do not imply job displacement, and should correlate primarily with productivity, as they measure tasks that can be performed more quickly with the help of generative AI. However, the lack of observable changes in demand may be due to the fact that it is still too early to witness its effects, as at least part of the impact of Generative AI has not yet materialised. On one hand, companies could decide to postpone both hiring and firing until the practical uses of new technologies materialise. On the other hand, labour markets may change as they integrate already available AI tools, as well as new ones still under development such as AI agents.

Impact on job quality: wages

While most studies in recent years conclude that technological change has a net positive effect on employment in quantitative terms, the qualitative impact of technological change cannot be neglected. How technology changes labour tasks and the work environment have important implications for job quality and ultimately for the well-being of workers., as will be discussed in Section 3.

Although the debate on job quality is not limited to wages, but to how technology shapes the broader work environment, this section focuses on wages as a general indicator to approximate job quality through its measurement, as it correlates with key labour variables for assessing job quality. In this regard, the impact of technology on wages is a widely debated issue, with studies pointing to different effects depending on the type of technology, industry, region and skill level (Figure 9).

One of the main effects of technological change is the shift towards higher-skilled and higher-wage occupations[74]. This phenomenon is linked to digitalisation, automa-

73 OECD, 2024 "Job Creation and Local Economic Development 2024: The Geography of Generative AI".
74 Goos, Maarten, Alan Manning, and Anna Salomons. 2014. "Explaining Job Polarization: Routine-Biased Technological Change and Offshoring" *American Economic Review* 104 (8): 2509-26; Choi and Lee (2020).

Polarising effect of technology

tion and technological innovation which, on one hand, have replaced many routine and manual tasks, but, on the other hand, have created new jobs that require higher technical, cognitive and specialised skills. The shift to higher-skilled occupations has a significant impact on wages. The automation of repetitive and low-level tasks reduces the demand for lower-skilled workers, which may lead to downward pressure on their wages. But automation also creates new job opportunities in technological and specialised sectors, which can lead to higher wages for those with the technical and specialised skills required to perform them. Several empirical studies have sought to determine these effects, but there is generally no consensus on whether wages increase with increased penetration of automation (Figure 9), although most support its polarising effect.

Generative AI and its potential impact on higher wages

Recent developments in AI allow for increasing automation of non-routine cognitive tasks, so that such developments may contribute to downward pressure on labour demand and a decoupling of productivity from wages. This could counteract the positive effect of higher productivity, which would otherwise increase labour demand, employment and wages, especially as, unlike previous waves of automation, generative AI could involve mainly highly skilled workers.

Although conducted at a very early stage of development of generative AI, to date the studies do not support the idea of a general decline in wages in occupations "exposed" to AI (Figure 9). Some even suggest a positive impact on wage growth, with larger increases experienced by people in higher-paid and/or better-educated occupations. This suggests that such people are better positioned to use AI to complement their own work, increase their productivity and share in the benefits.

Impact on inequality

While overall employment has continued to grow in the face of major structural changes, entire sectors of the economy have declined as a result of technological change, the ecological transition and other major trends. Over the last two decades, new employment has been created predominantly in service industries, while employment in manufacturing has declined, contributing to widening disparities between different groups of workers. Moreover, while new jobs continue to be created as a result of technological changes and the ecological transition, they are usually in different sectors, often in different regions, and frequently require other skills than those of the jobs that were lost. Technological change therefore entails difficult transitions that require active support of those who have seen their jobs changed or displaced by these forces, as well as a workforce that

FIGURE 9. IMPACT OF TECHNOLOGY ON WAGES. SELECTED STUDIES

Publication	Level of analysis	Countries	Technology type	Impact
Graetz and Michaels (2018)	Industry		Industrial robots	Positive
Acemoglu and Restrepo (2020)	Regional	USA	Industrial robots	Negative
Dauth et al. (2021)	Regional	Germany	Industrial robots	Null
Chiacchio et al. (2018)	Regional	Finland, France, Germany, Italy, Spain and Sweden	Industrial robots	Negative (not robust)
Goos, Manning and Salomons (2014)	Country	UK, USA, Netherlands	Automation, Digitalisation	Wage polarisation
Arntz, Gregory and Zierahn (2016)	Country	OECD countries	Automation, AI, Digitalisation	Wage polarisation
Brynjolfsson and McAfee (2014)	Global	Global	Digitalisation and automation	Wage polarisation
Freeman (2015)		USA, Europe	Automation, Digitalisation, AI	Wage polarisation
Chui, Manyika and Miremadi (2016)	Global	Global	*AI, Automation, Big Data*	Increased salaries in creative and technological areas
Felten, Raj and Seamans (2019)	Occupations	Global	AI	Positive
Fossen and Sorgner (2019)	Individual	USA	AI	Positive. Especially among those with higher wages and/or higher levels of education.
Acemoglu et al. (2020)	Industry and occupations	USA	AI	Null.

Source: Authors' own.

actively engages in processes of *upskilling* and *reskilling* in order to integrate them into new work contexts.

Workers (personnel)

Generative AI is leading to major shifts in the impact of technology on labour markets, as previous waves of innovation – involving not only digital but also other technologies – had a greater impact on the less educated workforce, which was more exposed. Several studies show that less educated workers tend to be significantly more exposed to automation (Figure 10). Conversely, those with higher levels of education are more exposed to generative AI

(Figure 10), which does not usually translate into a higher risk of job loss or downward pressure on their wages. In other words, higher-skilled and higher-earning workers are, on average, more exposed to AI, but they are also better positioned to exploit its potential as a complement to improve both their productivity and quality of work, provided they acquire and keep up to date with the necessary digital skills. This difference is expected to remain the same or grow as the lower and higher skilled groups equalise their exposure to generative AI over time[75].

AI tools have a high potential to act as a complementary tool[76] in occupations requiring a high level of cognitive engagement and advanced skills. People engaged in these occupations will therefore be better positioned to benefit from productivity gains, while minimising the risk of job losses.

In terms of gender, there is no clear link to the degree of exposure to technology (Figure 10). Some studies suggest that men tend to occupy jobs with a higher risk of automation. Others estimate that women, despite being employed in occupations less likely to automate, perform many tasks that may be automated and are therefore at greater risk. With regard to AI, the few studies conducted to date conclude that there is little difference. While men are more exposed to AI in their jobs, especially in technology and development[77], women are gaining ground and tend to be in jobs that are expected to be more exposed to generative AI[78].

Regional

Technological change has also contributed to increasing regional imbalances as the labour displacement effect of new technologies is especially strong in regions with a higher concentration of firms in routine task-intensive industries. A common pattern is that large metropolitan areas tend to be exposed to a lower risk of automation, while rural and other urban areas have a higher proportion of occupations that may be automated.

However, unlike previous automation technologies, generative AI excels at performing cognitive and non-routine tasks, which changes the regional labour market exposure, with regions that concentrate activities such as education, ICT or finance becoming the most exposed to generative AI. Thus, regions previously considered to be at comparatively low risk of automation would now be the most exposed to generative AI, and also most able to take advantage of its eventual positive effects. On the other hand, the regions least affected by exposure to generative AI are those that are less technologically developed or more dependent on traditional sectors.

75 Felten, Edward W. and Raj, Manav and Seamans, Robert (2023), "Occupational Heterogeneity in Exposure to Generative AI"; and Georgieff and Hyee (2021).

76 Pizzinelli, C., Panton, A. J., Mendes Tavares, M., Cazzaniga, M., & Li, L. (2023). "Labor Market Exposure to AI: Cross-country Differences and Distributional Implications". IMF Working Papers, 2023(216).

77 Brynjolfsson & McAfee (2018).

78 Gmyrek, P., J. Berg and D. Bescond (2023), "Generative AI and jobs: A global analysis of potential effects on job quantity and quality", ILO Working Paper 96.

FIGURE 10. SUMMARY OF EXPOSURE TO TECHNOLOGY ACCORDING TO PERSONAL CHARACTERISTICS. SELECTED STUDIES

Personal Characteristics	Publication	Level of analysis	Technology type	Link to Automation/AI exposure
Educational level	Frey and Osborne (2017)		Automation	Negative
	Fuei (2017)		Automation	Negative
	Nedelkoska and Quintini (2018)	OECD countries	Automation	Negative
	Pouliakas (2018)		Automation	Negative
	Pajarinen et al. (2015)		Automation	Negative
	Antz et al. (2016)		Automation	Negative
	Brynjolfsson and McAfee (2018).		AI	Positive
	Georgieff and Hyee (2021)		AI	Positive
	Felten, Raj and Seamans (2023)		AI	Positive
	OECD 2024	OECD countries	AI	Positive
Sex (Gender)	Pouliakas (2018)	European countries	Automation	Men greater exposure
	Banno et al. (2021)	Italy	Automation	Men greater exposure
	Mason (2021)	USA	Automation	Men greater exposure
	Nedelkoska and Quintini (2018)	OECD countries	Automation	Women greater exposure
	Haiss et al. (2021)	Austria	Automation	Women greater exposure
	Ill'essy et al. (2021)	Hungary	Automation	Same exposure
	Pajarinen et al. (2015)	Finland	Automation	Same exposure
	David (2017)	Japan	Automation	Same exposure
	Frenette and Frank (2020)	Canada	Automation	Same exposure
	OECD 2024	OECD countries	AI	Same exposure

Source: Authors' own.

Wages

In terms of labour income, some workers may also benefit more than others from technological changes. Earlier waves of technological progress were associated with the automation of routine tasks and, therefore, these technologies primarily affected people in low - and medium-skilled occupations, contributing to an increase in the wage gap between those with high and low skills[79]. Most empirical studies on the effects of automation technologies on wages have focused on industrial robots, and most of these studies suggest that substitution prevail (Figure 9). As a result, industrial robots have tended to increase inequality by widening the wage gap between the most exposed occupations (typically routine and manual occupations) and the least exposed occupations (typically managerial or higher occupations).

However, as noted above, recent developments imply that AI also affects non-routine cognitive tasks, extending its reach to skilled profiles[80]. Research focusing specifically on AI is less common, and, so far, finds no evidence that it has affected wage inequality between occupations[81]. In contrast, there is growing evidence that the use of generative AI can reduce performance differences between people in the same occupation[82], which could have an impact on wage gaps within the same profession, as a recent OECD study seems to support[83]. However, extrapolations to the current context should be made with caution as the studies to date were conducted at a time when AI uptake was still relatively low and excluded its most recent developments.

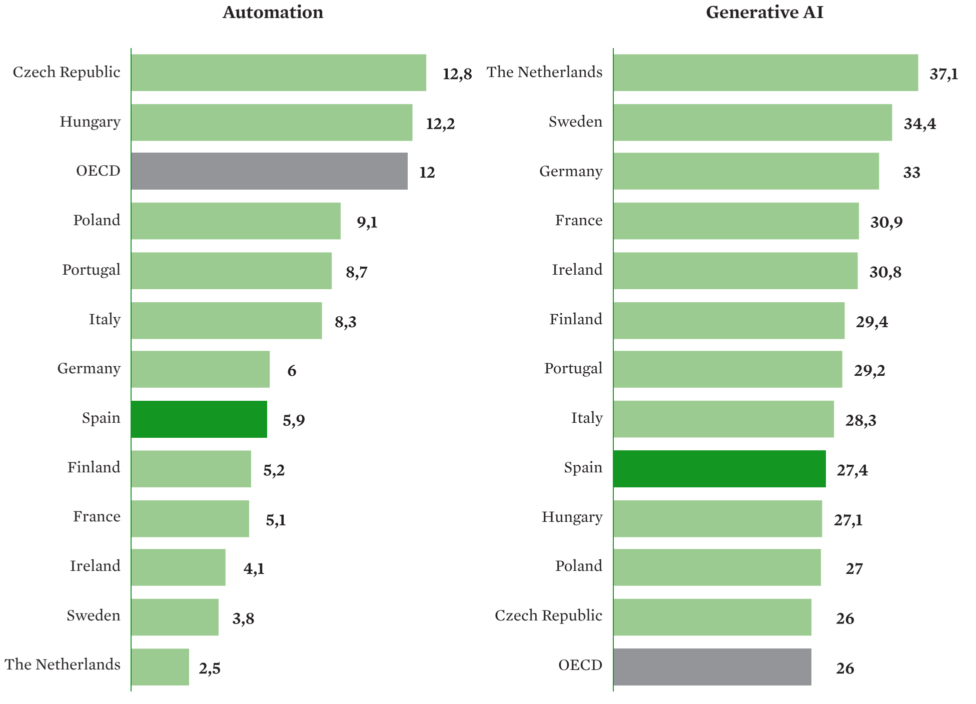
1.2. SITUATION AND PERSPECTIVES IN SPAIN

Impact on the volume of employment

According to the OECD, the percentage of employment exposed to automation in Spain is below average, at 5.9 per cent, compared to an average of 12 per cent (Graph 7)[84]. This reflects the progress made in the process of tertiarisation of the Spanish economy and the automation of its industry since the 1990s, and since the start of this century, of other sectors such as services, retail trade, logistics and transport. A process that was largely completed in the first decade of this century as demonstrated by the fact that there has been little change in the number of employed persons in the ten occupations most exposed to automation in the last decade, growing at the same rate as the rest of the occupations less exposed to technology (Graph 8). In terms of employment volume, while some sectors and occupations have been affected, new employment opportunities have also been generated so that, in aggregate and in line with global trends, the number of jobs in Spain has grown over the last decade (Graph 8).

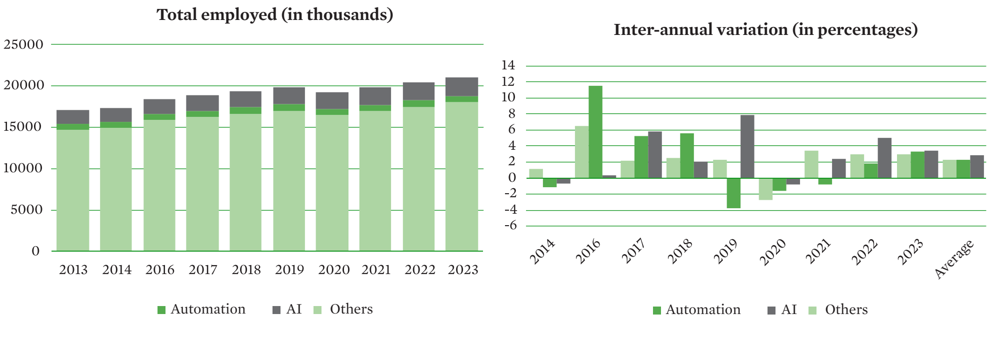
79 Dauth et al., 2017; Acemoglu and Restrepo, 2020; Webb, 2020.
80 Lane and Saint-Martin, 2021; Lorenz, Perset and Berryhill, 2023.
81 Acemoglu et al. 2020; OECD 2024.
82 Brynjolfsson, Li and Raymond, 2023; Choi and Schwarcz, 2023; Dell'Acqua et al., 2023; Haslberger, Gingrich and Bhatia, 2023; Noy and Zhang, 2023; Peng *et al.,* 2023.
83 OECD 2024.
84 This report's measure of automation exposure takes into account all advanced automation and AI technologies available by the end of 2021 and is therefore useful for examining the effects of automation technologies prior to the development of generative AI. In particular, the measure considers occupations to be at high risk of automation if more than 25 per cent of their competences and skills may be automated to a high level with available technologies.

GRAPH 7. EMPLOYMENT EXPOSED TO TECHNOLOGICAL CHANGE, 2022 (Percentage)



Source: OECD, 2024 "Job Creation and Local Economic Development 2024: The Geography of Generative AI".

GRAPH 8. EMPLOYMENT TRENDS IN OCCUPATIONS MOST EXPOSED TO TECHNOLOGICAL CHANGE IN SPAIN, 2013-2023



Source: Authors' own based on microdata from the Survey of the Working Population (INE).

In contrast, just over a quarter of employment is exposed to generative AI (Graph 7). This shows that Artificial Intelligence, in its various applications, could have a considerable impact on the Spanish labour market, changing both the nature of jobs and the way work processes are organised in different sectors. The impact will be uneven depending on the sector, region and workers' qualifications as will be seen in the following section. While the most exposed occupations and sectors may suffer from lower demand and transformation of their tasks, new jobs will also be created, as suggested by the fact that employment in the most AI-exposed occupations has grown at a faster pace (Graph 8).

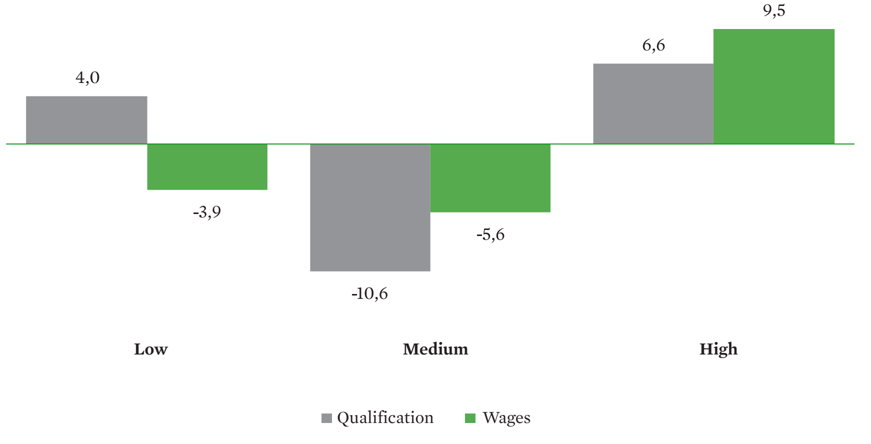
Impact on job quality: wages

In Spain, in line with the structural changes associated with global technological change, there has been a shift in employment towards higher-skilled and higher-paid occupations. Employment in higher quality occupations specifically has almost doubled in just 25 years, growing by 10 percentage points when considering wages and by almost 7 percentage points when considering skill levels (Graph 9).

As regards the evolution of wages in Spain according to the degree of exposure to technology, in nominal terms they have grown more in occupations more exposed to AI, and less with regard to the set of occupations more exposed to automation technologies prior to AI (Graph 10).

By sector, it highlights how those with high exposure to technology (such as technology, telecoms, finance and digital health) have experienced significant wage growth (Graph 10). On the other hand, traditional sectors have seen more modest or stagnant wage growth, especially those with less digitalisation and automation, which has widened the wage gap between professions with high exposure to technology and those requiring less specialised skills (such as manual work or in some services).

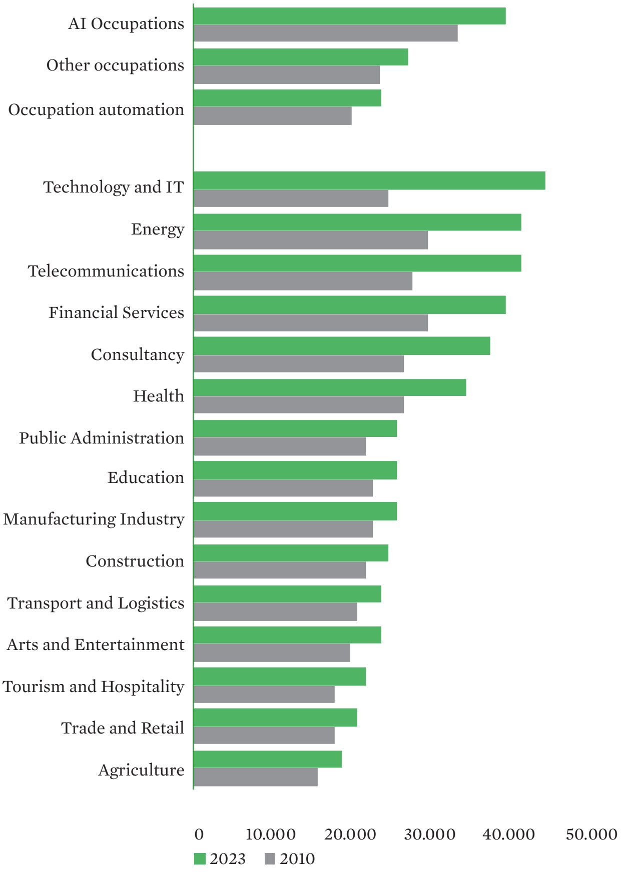
GRAPH 9. STRUCTURAL CHANGES IN EMPLOYMENT IN SPAIN RELATED TO TECHNOLOGICAL CHANGE, 1999-2024 (Percentage points)



Note: High-skilled occupations include jobs classified in major groups 1, 2 and 3 of the Spanish National Classification of Occupations (CNO), i.e. Management of enterprises and public administration (1). Professionals and senior technicians (2). Support technicians and professionals (3). Medium-skilled occupations include jobs classified in the major groups 4, 7 and 8 of the CNO, i.e. clerical workers (4), craftsmen and skilled workers in industry and construction (7), operators of fine and mobile plant and machinery, and assemblers (8). Low-skilled occupations include jobs classified in major groups 5 and 9, i.e. workers in security, personal, hospitality and retail sales (5), elementary occupations (9). High-, medium - and low-wage occupations are divided according to terciles.

Source: Authors' own with data from the Survey of the Working Population (EPA) and the Wage Structure Survey (National Statistics Institute – INE).

GRAPH 10. EVOLUTION OF WAGES BY SECTOR AND IN THE OCCUPATIONS MOST EXPOSED TO TECHNOLOGICAL CHANGE IN SPAIN, 2010-2023 (Nominal Euros per annum)



Source: Author's own based on INE data (Survey of the Working Population and Wage Structure Survey) and consultancy reports (Randstad, Adecco, Michael Page).

This phenomenon has been driven by the digitalisation of the economy and the increasing demand for digital skills. Companies in sectors such as applications development and Artificial Intelligence are willing to pay higher salaries to attract and retain specialised talent. This has led to a growth in salaries in these fields, which has made technology professions more economically attractive compared to traditional professions.

Impact on inequality

As is the case globally, technological change in Spain has a heterogeneous impact depending on the type of occupation, which affects the levels of inequality between individuals, groups and regions. In order to assess the degree of exposure to technology in Spain according to personnel characteristics, this analysis has previously defined the ten occupations most exposed to automation and AI, respectively[85].

With regard to automation, occupations involving routine and repetitive tasks, and those that rely on manual skills and strength, tend to be more exposed (Figure 11). According to the Survey of the Working Population (EPA), men, non-nationals and low-skilled youth tend to be over-represented in most of these occupations. However, the main determinant is educational level, as shown by the fact that a worker with no secondary education is almost 14 percentage points more likely to work in an automation-exposed occupation than a person with the same socio-demographic characteristics but with a university education (Graph 11). Low-skilled persons are therefore most vulnerable to job loss or job changes due to automation.

With regard to AI exposure, given that the greatest advances have been in non-routine cognitive tasks, many of the most exposed occupations, including the latest advances in generative AI, are white-collar occupations that typically require several years of formal training and/or tertiary education, e.g. IT professionals, managers, and science and engineering professionals. Thus, among the socio-demographic characteristics considered, education is also the most important determinant of AI exposure (Graph 11).

Not only do the most exposed occupations have a large proportion of highly educated people, but education also negotiates the relationship between AI exposure and other socio-demographic characteristics. Thus, native, middle-aged and older people are among the groups most exposed to AI, partly because they tend to be in more highly educated professions.

On the other hand, women have a slightly higher exposure to AI, which is again a change from previous automation technologies. Additionally, while men are over-represented in certain occupations linked to technology and software development (Figure 11), women tend to be in jobs that are more exposed to generative AI. The estimates carried out in this sense with data for Spain shows that women of Spanish nationality, under 50 years of age and with a university education are approximately 1.4 percentage points more likely to have a job exposed to AI than a male worker with the same characteristics (Graph 11).

Finally, it is possible that current inequalities between regions may widen with the expansion of AI. According to the OECD[86], Madrid is the region with the highest exposure to AI, with 36.6 per cent of jobs exposed to this technology, well above the national

85 For this purpose, we have converted to 3-digit CNAE (Spanish National Classification of Economic Activities) the 3-digit ISCO occupations identified as most exposed in Dario Guarascio, Jelena Reljic, Roman Stöllinger: Diverging paths: AI exposure and employment across European regions, Structural Change and Economic Dynamics, Volume 73,2025.

86 The OECD report does not assess whether AI will modify or directly eliminate jobs by being able to carry out the same tasks autonomously, and limits itself to assessing the exposure of jobs, as a whole, to the new technological tools that are being developed for application in different work environments.

FIGURE 11. CHARACTERISTICS OF WORKERS IN OCCUPATIONS MOST EXPOSED TO TECHNOLOGICAL CHANGE IN SPAIN, 2023 (Percentages)

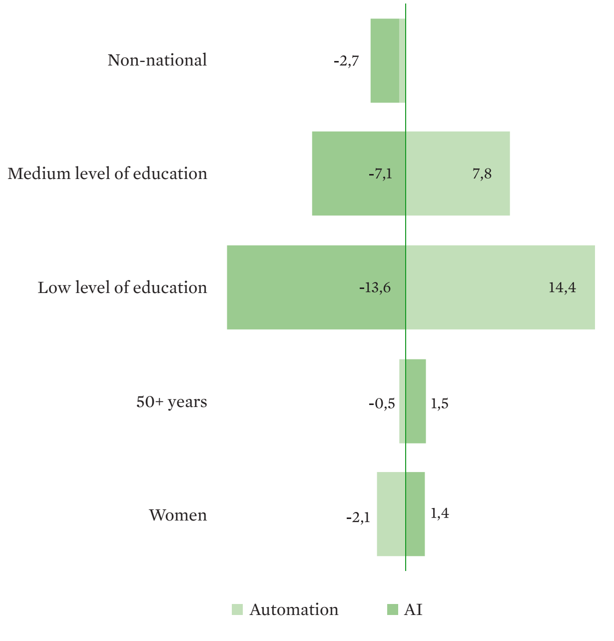
Occupations most exposed to automation	**Women**	**National**	**25-49 years**	**50+ years**	**University education**
Fishery, aquaculture, forestry and hunting workers	11,8	83,3	52,1	37,2	8,0
Food, beverage and tobacco industry workers	42,7	76,6	62,8	31,3	6,9
Cabinetmakers and related workers	9,1	88,9	58,5	39,0	7,4
Textile, garment, fur, leather and footwear workers	57,9	82,5	41,4	51,2	7,7
Assemblers and factory assembly workers	25,3	87,4	66,2	27,9	4,5
Operators of mobile agricultural and forestry machinery	1,0	81,7	59,5	33,2	1,6
Metal processing plant operators	8,4	87,4	59,4	32,5	5,0
Operators in wood treatment and transformation, paper manufacturing plants...	25,3	87,8	53,0	39,9	5,8
Operators of other mobile machinery	3,7	92,4	61,8	34,2	1,7
Woodworkers and related workers	17,3	84,7	54,3	40,3	5,0
Average	**20,2**	**85,3**	**56,9**	**36,7**	**5,3**
Occupations most exposed to AI					
Physicists, chemists, mathematicians and related disciplines	49,8	90,4	76,1	17,6	100,0
Finance specialists	53,5	89,8	70,5	22,5	97,3
Judges, magistrates, lawyers and prosecutors	54,3	96,4	51,2	47,4	100,0
Specialists in organisation and administration	59,1	94,6	57,1	39,5	98,7
Accounting and finance employees	67,5	92,7	61,9	34,0	47,1
University and other higher education teachers	49,2	94,8	45,9	53,4	100,0
Other administrative staff without front-office duties	73,0	94,0	55,5	40,6	33,5
Commercial, advertising, public relations and Research and Development managers	38,6	86,1	57,6	41,8	75,2
Software and multimedia analysts and designers	24,6	89,5	81,6	13,9	94,3
Secondary school teachers	58,9	97,0	62,7	36,1	99,0
Average	**52,8**	**92,5**	**62,0**	**34,7**	**84,5**
Total jobs	**51,0**	**87,0**	**33,4**	**42,0**	**19,7**

Source: Authors' own based the Survey of the Working Population (National Statistics Institute – INE) and Dario Guarascio, Jelena Reljic, Roman Stöllinger: Diverging paths: AI exposure and employment across European regions, Structural Change and Economic Dynamics, Volume 73,2025.

average (Graph 12), which is explained by the greater weight of sectors such as technology, banking, telecommunications and the public sector, which are rapidly adopting these technologies. On the other hand, regions less affected by exposure to GenAI are those that are less technologically developed or more dependent on traditional sectors. In Castile-La Mancha, for example, only 19.6 per cent of jobs are exposed to artificial intelligence, a considerably lower figure than in Madrid. This reflects the economic and technological disparities between the different regions of Spain, where rural or less urbanised areas have a lower level of exposure to AI, as opposed to the risk of automation.

To conclude, employment in Spain is unlikely to be affected extremely negatively due to Artificial Intelligence, but it will face a process of transformation in the nature of the work. As we shall see in the next section, the key will be to adapt the workforce to new technologies. Regional and personal differences in exposure to GenAI indicate that training and adaptation policies should take into account territorial and personal diversity, with especial focus on areas and individuals most vulnerable to technological change. With the right policies, Spain can harness Artificial Intelligence to foster inclusive and sustainable economic development, preparing its citizens for the jobs of the future.

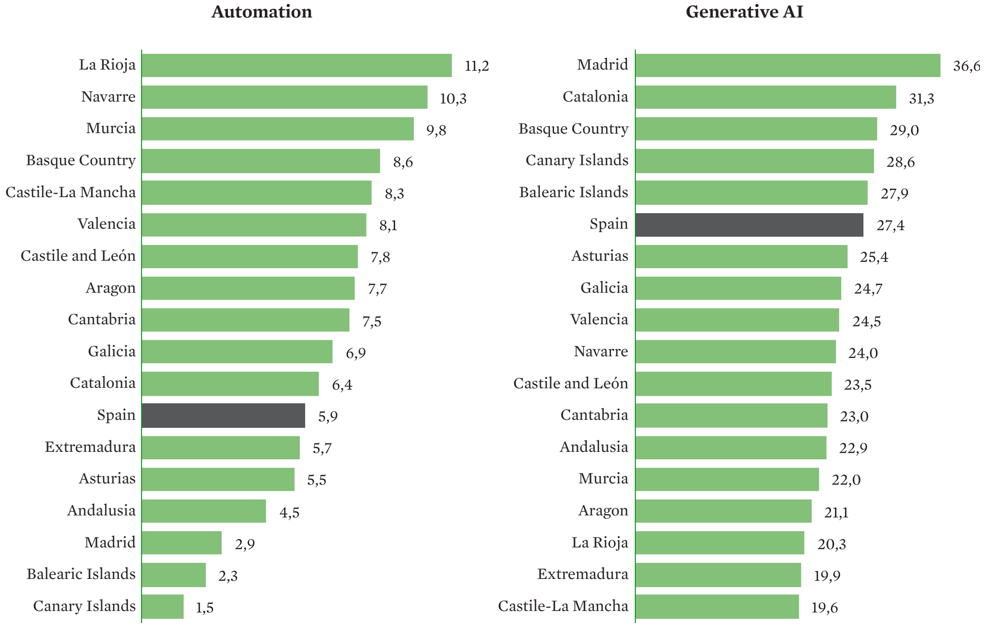
GRAPH 11. CHARACTERISTICS OF WORKERS IN OCCUPATIONS MOST EXPOSED TO TECHNOLOGICAL CHANGE (Percentage points)



Note: The graph shows the coefficients of a logistic regression controlling for age, gender, nationality and educational level. The coefficients represent the marginal effect (i.e. the average change in probability). For example, women in 2023 are approximately 1.4 percentage points more likely to have an AI-exposed job than men when controlling for all other sociodemographic characteristics.

Source: Authors' own based on microdata from the Survey of the Working Population (National Statistics Institute – INE).

GRAPH 12. JOBS EXPOSED TO TECHNOLOGICAL CHANGE IN SPAIN, 2022 (Percentage)



Source: OECD, 2024 "Job Creation and Local Economic Development 2024: The Geography of Generative AI".

2. Active labour market policies as a response to the challenges of technological change

Labour market policies seek to encourage workers' adaptation to technological change and, specifically, to the rise of Artificial Intelligence. This involves different areas of action. In the first place, it involves promoting, from the educational and vocational training sphere, the qualification, requalification and acquisition of skills required to ensure a good performance in the employment environment defined by AI. It also involves a prospective analysis of the labour market as an observatory of occupations and tasks. It also includes minimising prospective risks and vulnerabilities faced by workers from the introduction of AI and avoiding, in any case, its continuance and long-term effects.

Furthermore, a key element of labour market policies has to do with managing the changes brought about by AI in the provision of active labour market policies through employment services. Such changes affect the functioning of the services (profiling, intermediation, recruitment), the composition and time dedicated to the tasks of the employment services or their relationships with users and businesses, while promoting greater efficiency of job insertion and actions to support employability. At the same time, harnessing this potential brings with it significant challenges related to the "explainability" of AI decisions, non-discrimination of certain user profiles, ensuring data protection, or the possibility of turning the increased generation of data and information towards evaluation.

AI skills and training in Spain

According to comparative data from Cedefop's AI skills survey, the first comparative survey focusing on this topic, more than a quarter of all workers in the EU currently use some form of AI tool in their workplace[87]. This figure suggests a significantly higher level of adoption than that reported by related statistical sources analysing AI adoption in enterprises, and should therefore be interpreted with caution[88]. However, it does point to some interesting trends for the analysis of AI skills in our country. In this sense, the use of AI by workers in Spain is lower than in the other countries surveyed and, moreover, the rate of adoption in our country is also somewhat slower (Graph 13). Despite this, around half of all workers surveyed report a need for training in this area (Graph 13).

This underlines the importance of equipping and promoting the skills needed to cope with JOB transformations resulting from digitalisation and AI. These two areas are closely interlinked[89] and, given their cross-sectoral and general-purpose nature, generate training requirements in practically all occupations, as is regularly pointed out by prospective analyses of the Spanish labour market[90].

Given Spain's comparative lag, active employment policies must urgently address existing digital skill gaps among workers – both employed and unemployed (Graph 14)- and, in the face of the challenges posed by AI, promote the necessary guidance, intermediation, training or support actions to enhance the employability of all workers, leaving no one behind, as well as respond to the needs of the production sector, while providing guidance towards responsible AI design and usage that avoids harming workers, companies or third parties.

Application of AI in the provision of active labour market policies. Opportunities...

Furthermore, active labour market policies have the opportunity to increase the efficiency and effectiveness of their actions through AI[91]. Thus, integrating AI in employment services offers prospects for improvement in the different phases of the labour market insertion process, promotion of employability, and prevention of labour market mismatches (Figure 12).

87 Cedefop (2025): *Skills empower workers in the AI revolution, First findings from Cedefop's AI skills survey*.

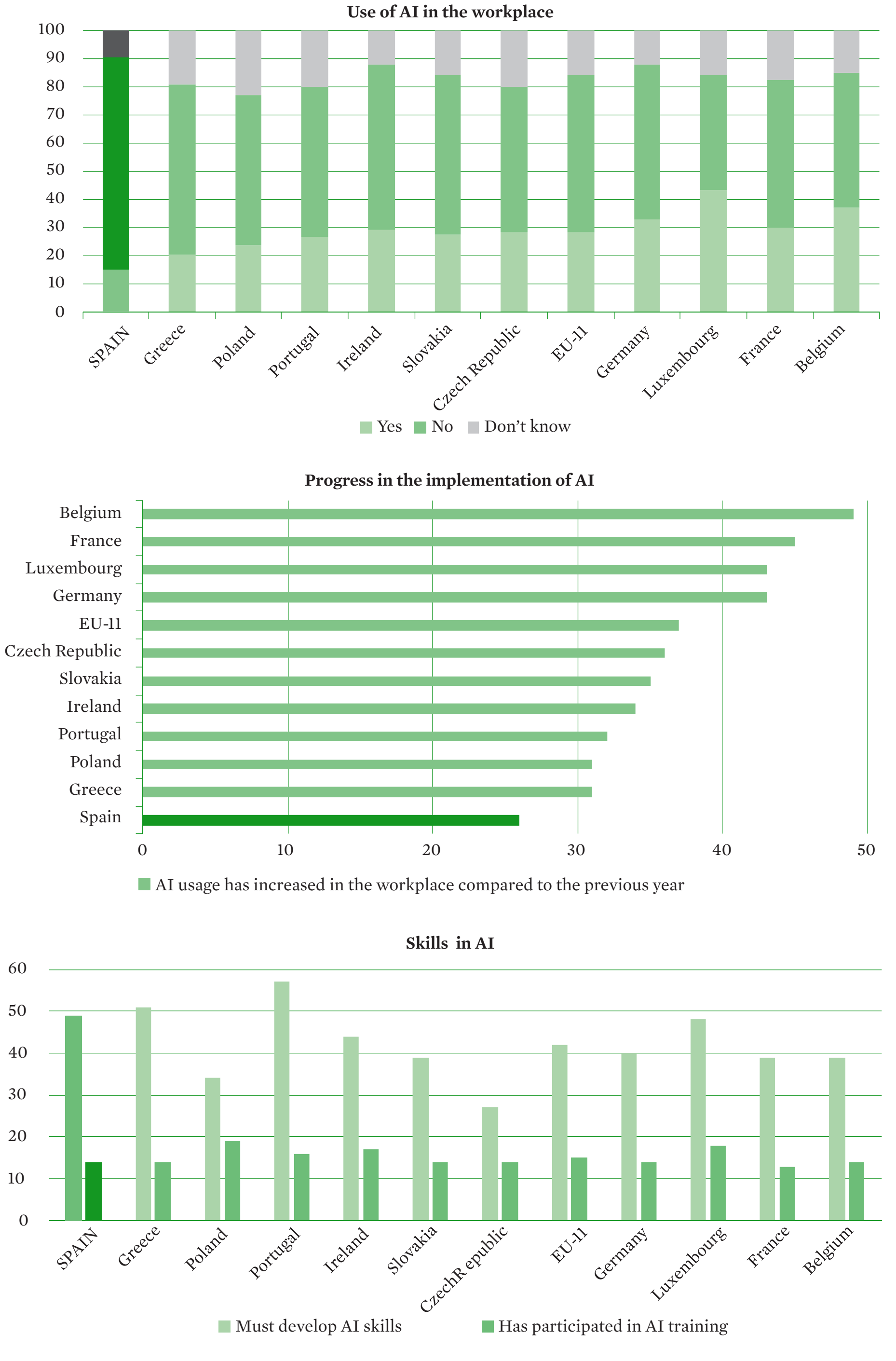
88 According to the National Statistics Institute's (INE) Survey on ICT and e-Commerce (EC) use in companies, 12.4 percent of enterprises with more than 10 employees and 7.5 percent of companies with less than 10 employees use some form of AI-related technology (data for the first quarter of 2024). According to Eurostat's Survey on ICT Usage in Enterprises, this percentage rises to 13.5 per cent in the EU-27 (data only available for enterprises with more than 10 employees). Beyond the methodological differences between different sources, it should be stressed that the positive responses in the Cedefop survey refer to both the use of AI by the respondent directly and by a colleague in the same workplace. This means that the results may reflect a double counting which may in turn explain the positive bias.

89 European Commission-DG EMPL (2025): *Joint Employment Report*, pp. 38 et seq.

90 SEPE-Observatorio de las ocupaciones (2024): *Informe de prospección y detección de necesidades formativas*.

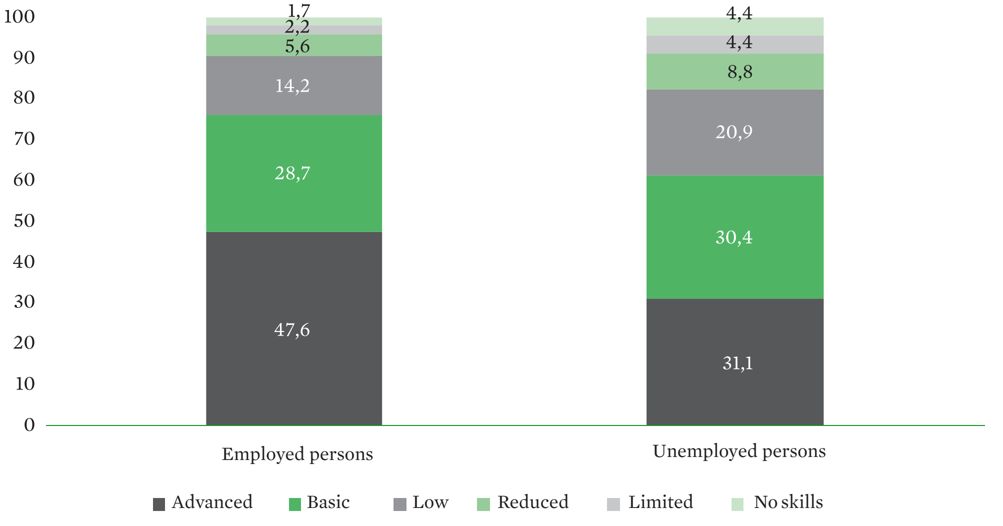
91 This is recognised in the EESC Opinion C/2025/1185 'Pro-worker AI: levers for harnessing the potential and mitigating the risks of AI in connection with employment and labour market policies'; point 4.1.2.

GRAPH 13. AI USE, IMPLEMENTATION RATE AND TRAINING REQUIREMENTS IN SPAIN AND OTHER EU COUNTRIES, 2024 (Percentage)



Source: Cedefop (2025): *Skills empower workers in the AI revolution, First findings from Cedefop's AI skills survey*.

GRAPH 14. DIGITAL SKILLS OF THE POPULATION BY EMPLOYMENT STATUS, 2023 (Percentage)



Source: FUNDAE (2024): *Profile of persons trained in digitalisation actions. Year 2023*, Workbook 4/2024, based on INE, ICT_H Survey 2023.

...and challenges and risks

Although AI and algorithmic systems allow, *a priori*, more systematic and objective procedures for the management of active labour market policies, they also entail risks, challenges and precautions that must be addressed before incorporating the new technology into the routine activity of employment services.

AI-led changes and potential in the activity of employment services

An important part of the assumed potential of AI to promote employability in the opportunity it offers for employment services to focus on the most productive and impactful tasks. According to some estimates (Graph 15), integrating AI would significantly reduce the time dedicated to administrative or bureaucratic tasks, which currently consume an important part of the work time of employment services staff, and would make it possible to work more intensively and directly with the people and entities using it in orientation and intermediation tasks, which are those with the greatest return in terms of insertion[92].

Naturally, harnessing this potential involves supporting the development of skills and providing AI-related support resources to employment services staff. It is also a necessary complementarity in order to take advantage of the modernisation (digitalisa-

92 European PES Network (2025): *Opportunities of AI within PES processes and services*; Z. Lado and M. Boquete (2024): 'La IA aplicada a los servicios públicos de empleo. Hacia un sistema de intermediación, orientación y formación basado en competencias profesionales', *Cuadernos del Mercado de Trabajo*, 12, November.

FIGURE 12. POTENTIAL APPLICATIONS OF AI IN EMPLOYMENT SERVICES ACTIVITIES

Profiling of job seekers:

- Characterisation and classification of job seekers to facilitate job orientation tasks.
- Calculating the probability of employment on the basis of individual data and characteristics of the job seeker and in specific time frames (e.g. 3 months, 1 year, etc.).

Personalised services

- Matching job seekers to interventions, and active labour market policies programmes according to their requirements. For example, *Pôle Emploi* in France uses AI to identify job seekers with the greatest re-employment difficulties at an early stage. Using AI for assignment to employability actions can decrease the time spent unemployed (according to some studies, the reduction is as high as 20 per cent in the case of Flanders).
- Integration of external databases (on socio-economic conditions, on performance in previous work experiences, results in previous programmes, etc.) for further fine-tuning of interventions.
- Determining the fulfilment of conditions for access to training opportunities, recruitment subsidies, etc. by job seekers.
- Identify employment opportunities for specific profiles or added difficulties for labour market insertion (e.g. in the case of people with disabilities, if information on commuting distance, availability of transport or accessibility in companies is included).
- Information and job orientation (*chatbots*)
- Detection of irregularities in the provision of services and interventions (warning of biases, neglect of claimants, etc.)

Improved matching between labour supply and demand:

- Creation and enhancement of profiles by analysing resumes, detecting and enhancing key skills or experiences. For example, the *Jobbereik* tool of the employment service of Flanders in Belgium expands job placement options by proposing new occupations not covered by applicants, after analysing their skills, available vacancies and training possibilities. In France, AI analyses CVs for skills that are not explicitly mentioned.
- Optimisation of job offers. For example, by using keywords that promote and focus the search among targeted candidates; the use of terms that promote diversity and avoid self-exclusion of some groups of workers (women, workers of foreign origin, etc.).
- Detection of training gaps and matching with available training offers.
- matching competences or skills of job seekers with vacancies, including future vacancies resulting from prospective labour market analysis.

Market research and forecasting:

- Greater level of information and variables, which contributes to greater equality in decision-making.
- Better information and predictive capacity regarding employment needs in the market, specific sectors, etc.
- Support for workers' mobility on the basis of better information on offers. This information may be extended to source markets.
- Prediction of events with impact on employment: probability of unemployment, risk of company closures, etc.

FIGURE 12. POTENTIAL APPLICATIONS OF AI IN EMPLOYMENT SERVICES ACTIVITIES *(continued)*

Programme assessment:

- Analysis of the impact of programmes and services, enabling a higher level of attribution of results.
- Identification of best practices based on impact.
- Estimation of the probability of successful scaling up of programmes and interventions, incorporating environment-specific variables into the analysis.

Networking:

- Articulating employment services activities with equivalent institutions and other sectors at regional or municipal levels (interoperability and information exchange)

Source: Authors' own based on OECD (2022): 'Harnessing digitalisation in PES to connect people with jobs', *Policy brief on ALMPs*; S. Broecke (2023): Artificial Intelligence and Labour Market Matching', *OECD Social, Employment and Migration Working Papers*, No. 284 and OECD (2023): *Employment Outlook. Artificial Intelligence and the labour market; M. Urquidi and G. Ortega (2020): 'Inteligencia artificial para la búsqueda de empleo. Cómo mejorar la intermediación laboral en los servicios de empleo',* Inter-American Development Bank, Technical Note IDB-TN-01996 and the European PES Network (2025): *Opportunities of AI within PES processes and services*

tion) efforts of the employment services in recent years and which, have largely been channelled through the PRTR in Spain[93].

Most employment services in high-income countries report having provided their professionals with information guides and resources, training opportunities and specific support points, although no information is available on the in-depth nature of such resources[94]. In the case of Spain, it is necessary to redouble efforts to train professionals in digital tools and big data techniques, deemed a prior and complementary step to making full use of AI, promoting public-private collaboration and the sharing of good practices. Additionally, there is a shortage of data scientists specifically dedicated to the development of AI applications in employment services[95].

AI in the regulations on active labour market policies in Spain

In its analysis of AI's potential to address major long-term challenges in Spain, HispanIA 2040 estimated the effects of integrating AI into the National Employment System (SNE)[96]. The study predicts an increase in placements of between 78,700 and 131,000 people per year and

93 Previous Reports of the Economic and Social Council (CES) have analysed the nature, amount and implementation of investments dedicated to the digitalisation of employment services and active labour market policies in the PRTR. For a summary, see for example 2023 Report of the Economic and Social Council, p. 206 (Figure 10).

94 Brioscú, A. et al. (2024): A new dawn for PES services. Service delivery in the age of artificial intelligence', OECD Artificial Intelligence papers, No. 19, pp. 57-58.

95 Appearance of Marcel Jansen before the Working Committee set up to draw up the 2024 Report of the Economic and Social Council (ESC) 'Políticas activas de empleo: una agenda realista', 30th January.

96 National Office of Foresight and Strategy of the Government of Spain (coord.)(2025): *HispanIA2040: cómo la inteligencia artificial mejorará nuestro futuro*.

FIGURE 13. RISKS AND CHALLENGES POSED BY AI USAGE IN EMPLOYMENT SERVICES

Lack of robustness of AI tools

- Biases in algorithm training data, which may reproduce patterns of discrimination.
- Insufficient representativeness of data samples for certain groups of workers or categories of information.
- Incomplete data or low volumes of information hampers engine learning.
- As a result, AI can lead to unfair outcomes, both for workers and for companies, which lose options for recruiting talent and opportunities for diversity.
- Insufficient clarity regarding data usage protocols.
- Data security breaches.

Risks of discrimination and exclusion

- Technological gaps (access or lack of skills) in certain regions.
- Access barriers for persons with disabilities.
- Discrimination is less intuitive and more difficult to detect if it originates in the system's design or behaviour.
- Impossibility of detecting intangible or non-objectifiable elements of jobseekers and companies.

Transparency and explainability of decisions

- The need to inform job seekers that their profiles are being analysed by ai, specifying the information and profile elements studied.
- Opacity: ai tools can have a "black box" nature, when it is not possible to explain its decisions and results due to a lack of knowledge of the standards and criteria employed.
- Difficulties in attributing results to certain variables, determining weights for each factor, etc.
- For example, the *Jobnet* application launched by the public employment service of Flanders in Belgium faced the difficulty that the increasing sophistication of the system made it impossible to determine how the *matching* between job seekers and vacancies took place. This posed a problem of trust and transparency in the system, while at the same time preventing the establishment of general recommendations based on the results, as the specific contribution of the different variables was unknown.

Privacy

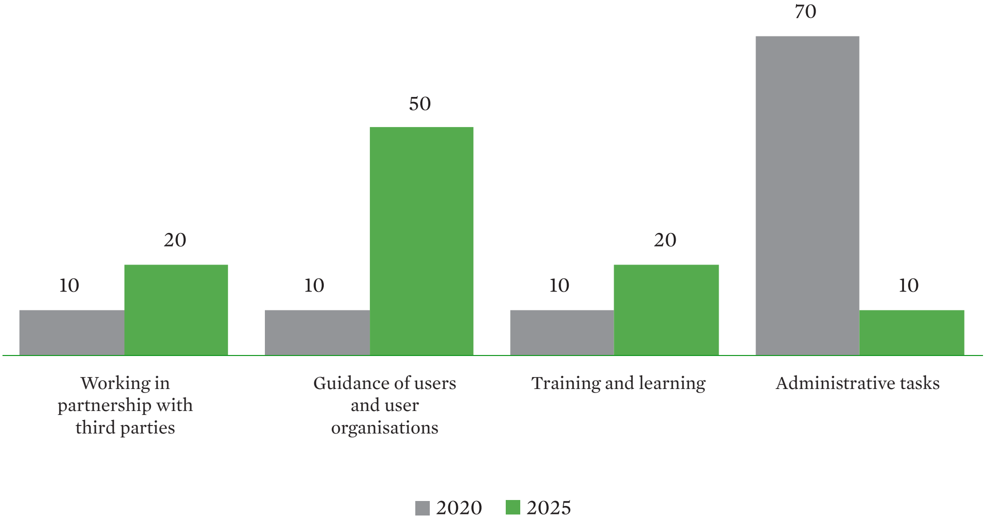
- The use of internet data (web scraping) raises doubts about consent to the transfer of data.
- The need to ensure the security of systems with regard to the use of personal and sensitive information on the persons and entities that use them.

Complementarity of AI with human control in PES

- The need to consider ai decisions as one element of decision-making and recommendation, not the only one.
- The need to train staff in data analytics to optimise the use of ai, interpret algorithms, etc.
- Maintaining both channels of interaction with employment services, especially important for profiles that have difficulties in accessing them.

Source: Authors' own and references from figure II-4.

GRAPH 15. DISTRIBUTION OF TIME SPENT ON THE TASK LOAD OF EMPLOYMENT SERVICES PROFESSIONALS, 2020 AND 2025 (Percentage of total)



Source: Hjartarson, J. et al. 2023. *Making it work. Global efforts to transform public employment services*, Deloitte.

estimates a positive impact of AI between 3 and 5 per cent in terms of the increased employability of job seekers.

The foundations for the implementation of AI in employment policies in Spain were laid in Act 3/2023 on Employment (Figure 14). In this sense, the law recognises the value and potential of AI to promote the necessary leap in quality, effectiveness and efficiency of active labour market policies, although specific initiatives to make this happen have yet to be substantiated and have not been incorporated into the ordinary activity of employment services. On the other hand, the standard includes certain provisions aimed at preventing and managing the main risks identified in the application of AI in active labour market policies.

3. Technological change and industrial relations. The role of social dialogue and collective bargaining

The introduction of new technological tools in companies has increasingly important consequences for labour relations. These effects are also becoming increasingly complex in line with the growing sophistication of available technologies.

In previous stages (the last two decades of the last century and first decade of this century), the availability of digital devices for work (computers, mobiles, etc.) connected to the internet enabled workers and companies to improve working conditions, make work more efficient and obtain productivity gains. But, at the same time, they have led to the emergence of new risks such as work intensification, lack of disconnec-

FIGURE 14. ARTIFICIAL INTELLIGENCE IN ACT 3/2023 ON EMPLOYMENT

Act 3/2023 on Employment promotes the use of AI as part of advanced analytical techniques that, based on the evidence provided, can support the work of employment services, the design of employment policies, and their assessment.

Opportunities offered by AI (according to the explanatory memorandum):

- Improving the **efficiency of the match** between labour supply and demand
- Increasing the **competitiveness** and **productivity** of the economy
- Providing quality and personalised **orientation services**
- **Improving the 'counsellor/job seeker'** ratio, as well as other indicators with the aim of closing the relative gap between spain and other eu countries in the field of active labour market policies.
- Maximising **coordination** between the spanish employment agency, regional employment services, trade unions, employers' organisations and educational bodies to create coherent and integrated public-private responses at the national level.
- Creating a **monitoring and assessment** system with key criteria such as the success of the job placement or the quality of the job obtained.

On algorithms:

The Act provides for the use of algorithms in decision-making and making recommendations (Art. 17). The algorithms, built on data analysis and statistical evidence provided by the Public Employment Service Information System (SISPE), will be implemented within the National Employment System in collaboration with the Autonomous Communities. They will subsequently be made available to the persons responsible for the individualised monitoring of job seekers, or to the persons responsible for the provision of services to individual users, companies or employer organisations.
The set of instructions that make up the algorithm underpinning the decisions and recommendations of the employment services are subject to regulatory development, which is still pending.

Accessibility, security and human control of the process:

- Guarantee of **accessibility** of technological tools for all users, and the obligation to make available **alternative channels or tools** for access to employment services and actions, with the aim of combating bias.
- Intermediary or placement actions **cannot rely exclusively on automated means**, but must involve human participation in the process. Decisions can always be **reviewed or modified** by the staff responsible for the individual follow-up and monitoring of each service user. In turn, the individual users, enterprises or employing entities shall have **access to the full content** of such decisions and recommendations.
- The use of ai is subject to **personal data protection**.
- **Annual assessment** of the decisions supported by the algorithm, similar to an audit, in order to report on possible modifications required for equal and non-discriminatory treatment.

Source: Authors' own based on Act 3/2023 on Employment.

tion, or technology fatigue. Additionally, the use of video surveillance and geolocation tools have posed new risks to workers' privacy and the use of their data.

The evolution of the technologies available and being incorporated in companies, always within the general technological context offered by digitalisation, has experienced an important leap with the algorithmic management (A.M.) in the workplace. A.M. has penetrated both salaried and self-employed work, mainly through digital platforms, which have pioneered this work structure, but it is also spreading to conventionally organised work.

PREVALENCE OF DIFFERENT TECHNOLOGIES AND EFFECTS AT WORK

This section starts by presenting, based on the available information, the current extent of the implementation of certain digital technologies in Spain compared to other advanced economies, and the effects on working conditions as reported by different studies. It should be noted that the sources for objective information on these issues, based on company and worker surveys, have improved in recent years, but even so, the information is still limited[97].

Use of digital devices

The use of digital devices at work has grown steadily in parallel with the digitalisation of the economy. The fourth European Survey of Enterprises on New and Emerging Risks (ESENER 2024)[98] reports widespread deployment of computers at fixed workstations (87 per cent of European enterprises) and increasing use of laptops, tablets, smartphones and other mobile devices (83 per cent of establishments, up from 77 per cent in the previous edition, ESENER 2019) across all business activities and sizes.

The implementation of this type of devices in the workplace has improved the performance of many tasks by eliminating long, tedious and repetitive processes by means of increasingly efficient software, shortening access times to the necessary information, making for more time flexibility and autonomy, and, in general, increasing performance, all of which can bring greater satisfaction in work performance.

97 For example, the latest edition of the European Working Conditions Survey (EWCS 2024) has included new questions on the occupational use of digital technologies, some related to the application of Artificial Intelligence such as the intensity of use of wearable devices (smart watches or smart glasses and other sensors) applied in data collection, the use of collaborative robots (cobots), of virtual interaction spaces or collaborative platforms, of Artificial Intelligence systems that simplify complex mental tasks or recommend how to work, or the extent to which technology has affected a person's work within the last three years (eliminating or creating new tasks, etc.).). Also, the extent to which it is a software that assigns tasks, tells workers when to work or monitors their work performance. And finally, if the person disagrees with the automated decision, whether he or she has a clear procedure for filing a complaint. However, the field survey of the last EWCS was completed at the end of 2024 and the initial results will not be available until the end of 2025.

98 European Agency for Safety and Health at Work (EU-OSHA), Fourth European Survey of Enterprises on New and Emerging Risks (ESENER 2024), first results.

However, the expansion of work with digital resources also entails new risks to the health and safety of people at work[99]. This is why it is important to incorporate the assessment of risks arising from digitalisation. This assessment is conducted in 43 per cent of companies in Europe and reaches more than 60 per cent in Spain, according to the first conclusions of the fourth ESENER. The main risk factors identified by this source, across all companies, are musculoskeletal disorders due to long hours of sitting (54 per cent of establishments using some form of digital technology indicate this as the number one risk factor), followed by repetitive movements (47 per cent), increased work intensity (34 per cent) and information overload (32 per cent). Between 20 and 30 per cent indicate the blurring of boundaries between work and private life, and the collection of data from workers.

Only one in three companies (35 per 100) report having consulted with worker representatives regarding the potential impact of digital technology on occupational health and safety, although this has improved compared to 2019 (24 per 100 according to the third ESENER).

Digital monitoring and surveillance at work

According to the Joint Research Centre (JRC) of the European Commission, using data from the AMPWork Survey[100], around two thirds of working people in Spain (65 per cent) and Germany (62 per cent) use digital devices at work, usually computers, most often combined with mobile devices (tablets and smartphones)[101]. These digital devices are often used to monitor and supervise work performance (working time, clocking in and out, computer usage, internet usage, voice calls or emails, location of persons or vehicles, and others). The most common practice is to monitor working time, which reaches 46 per cent of people in Spain and half of the working population in Germany, followed by the monitoring of entrances, exits and movements (39 per cent in Spain, 14 per cent in Germany). This study points out that physical monitoring by digital means is associated with monotonous work, lack of autonomy and lack of flexible working hours.

An important organisational element in the use of digital technologies for these purposes is transparency, i.e. whether the company informs employees about the use of digital technologies, as this is crucial for a better perception of the company and a better working environment. In Spain, 15.3 per cent of employees (5.4 per cent in Germany) reported that their company followed a policy of transparency regarding the information collected from them or their work activity, while 75.2 per cent said there was none. 11.6 per cent (5.8 per cent in Germany) reported having access to the digital information collected about them, compared to 76 per cent who did not have this access.

99 See Section 1.8.1. on action strategies and other occupational safety and health initiatives in chapter 2, 2024 Report of the ESC.

100 Algorithmic Management and Platform Work. It is based on the survey data of working people in Germany and Spain.

101 Fernandez Macías, E., Urzi Brancati, M.C., Wright, S. and Pesole, A. (2023), "The platformisation of work" (JRC Report), Publications Office of the European Union, Luxembourg.

The use of these technologies for such work organisation and coordination purposes poses the challenge of ensuring adequate personal data protection and the guarantee of digital rights.

Algorithmic Management (A.M.) in the workplace

A.M. is the use of automated monitoring and decision-making software or systems. For our purposes, it is the automation of work (and employee) management tasks that have traditionally been performed by executives and human managers. And it may or may not involve the use of Artificial Intelligence models, one of the most sophisticated and disruptive technologies available today. There are two main reasons behind this current interest in AI based A.M.: because AI is currently the central trend of technological change in the economy, and consequently in work, and above all because it poses the most novel and complex opportunities and risks for labour relations.

According to Eurostat data, in 2024, Spanish companies were somewhat below the EU average in terms of the general use of Artificial Intelligence (11.3 per 100 in Spain compared to 13.5 per 100 in the EU-27), and a long way behind the top-ranked countries (three Scandinavian nations: Denmark, Sweden and Finland, plus Belgium, all around 25 per cent). This is part of an upward trend in the use of this technology (since 2021, Spain has advanced 3.6 points, while the European average is 5.8). These data situate the country-based context in relation to the adoption of this advanced technology and examines the potential use of A.M. tools, especially AI-based management systems, by companies.

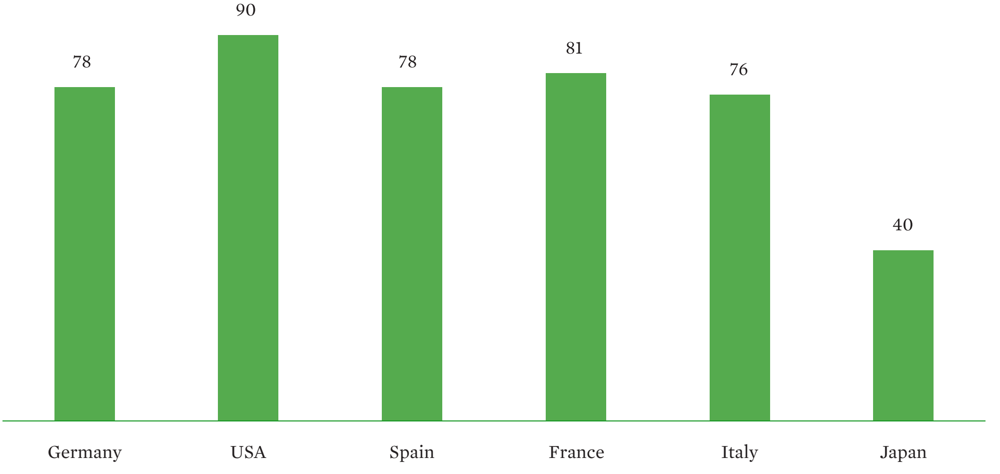
Recently, the OECD has quantified the prevalence of use of workplace A.M. tools in companies in a number of countries, including Spain (OECD, 2025). These are software tools for automated management tasks such as instructing, monitoring and assessing employees. Spain is in line with the main European economies in terms of the percentage of companies using some kind of A.M. tool (Graph 16).

And, similar to other European countries, it has a moderate (not intensive) degree of implementation of this type of tool by companies. Thus, the largest percentage of such enterprises (around 20 percent) use between three and five of the fifteen algorithmic management tools analysed in this study.

The study conducted by the JRC of the European Commission on the basis of the AMPWork Survey provides prevalence data from the perspective of workers[102]. It points out that around one-third of working people in Spain and around one in five in Germany are subject to some form of A.M. of their work, naturally through digital devices. Automated management via algorithms is performed in two main areas: in man-

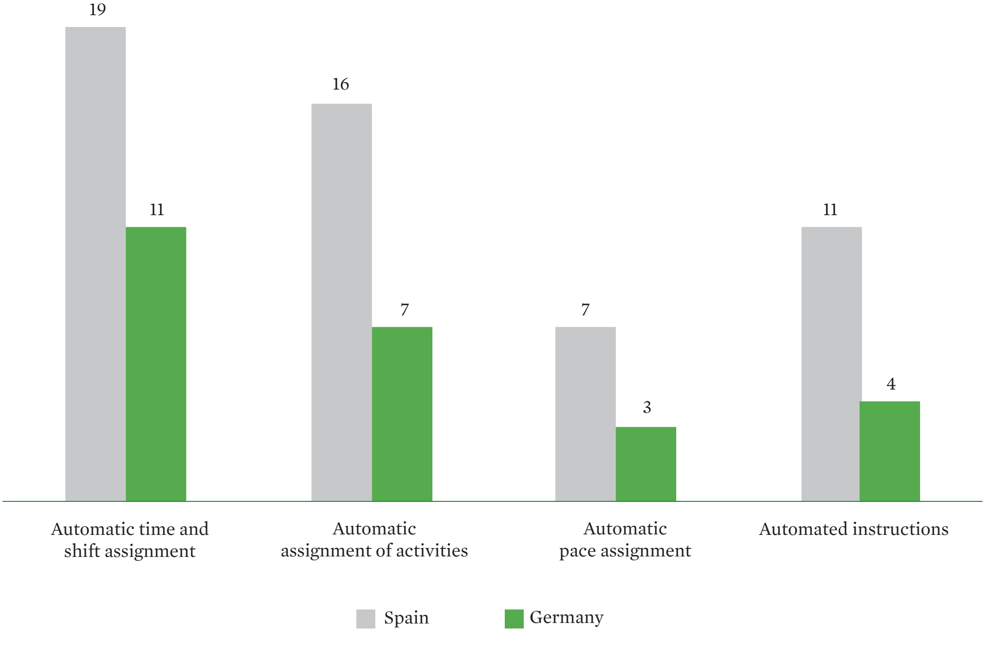
102 “The platformisation of work”, cit. See also Torrejón Pérez, S., González Vázquez, I. and Fernández-Macías, E. (2024), “Cambio tecnológico y empleo en la era digital”. Revista Cuadernos del Mercado de Trabajo, 2º semestre 2024 (available at https://www.sepe.es).

GRAPH 16. ALGORITHMIC MANAGEMENT IN THE WORKPLACE IN SELECTED OECD COUNTRIES, 2025 (Percentage of directors whose companies use some form of A.M. software)



Source: OECD employer survey on algorithmic management (2025).

GRAPH 17. ALGORITHMIC MANAGEMENT (A.M.) OF WORK PROCESSES (Percentage of people)



Source: JRC (2023), "The platformisation of work".

agement tasks and in performance evaluation. In the first of these, the most common form is the automated allocation of working times and shifts, followed by the assignment of activities and work schedules (Graph 17).

The evidence provided by these sources is still limited, not least because there is no distinction made between A.M. with and without AI models. While the latter can be simple computer programmes, AI-based systems must be trained on data derived from from monitoring workers' activity at work. It is no coincidence that the European Union's AI Regulation classifies such systems as high-risk, with the guarantees and requirements that this classification entails. However, they indicate that, in Spain as in other advanced economies, a significant proportion of companies and workers use some form of algorithmic, i.e., automated management system. Moreover, all forecasts suggest that the use of such work organisation tools will continue to grow, in line with the progress of digitalisation and an expansive technology as Artificial Intelligence.

A.M. can lead to improvements in work organisation. Its coordination via automated rules can lead to greater objectivity and consistency in decision-making, improving the predictability of instructions and neutralising possible biases in human decisions. Additionally, workplace data collection and analytics, combined with the use of AI models, can enable organisational innovations and productivity improvements, especially in certain activities and occupations.

On the other hand, however, field studies indicate that the A.M. of work management (automated management) is associated with complex activities and detailed procedures, and with less flexibility and autonomy of workers; and, from the point of view of working conditions, it is associated with more monotonous work and more work-related stress[103]. These aspects are accentuated in both management and working conditions when the A.M. is more intensive, to the point of what is described as a strong "platformisation" of work[104]. This is observed in 6.1 per cent of the employed population in Spain, while another 18 per cent reports a soft platformisation (1.3 and 9.7 per cent respectively in Germany); and it occurs to a greater extent in tertiary-educated workers, in professional, administrative and operator occupations, more in men (especially young people) than in women, but with a significant presence of women as well, and in high-tech industries, knowledge-intensive services and education[105].

The A.M. of work, especially when based on the application of AI models trained on data collected from people and/or their work activity, also poses challenges that must be addressed in industrial relations. Such challenges are related to algorithms applied in automated work management and assessment, information on the parameters used for their configuration, ensuring human control in decision-making on workers. The goal is to avoid discriminatory bias based on gender or other personal circumstances in

103 Regarding the health and safety implications of AI management of workers, see Section 1.8.1. on action strategies and other initiatives in this chapter.

104 JRC (2023), "The platformisation of work", cit. pp. 34 and 37. For the purposes of this study, the "platformisation of work" implies the digital and algorithmic management of work (depending upon application or non-application of AI systems) in the conventional economy, which brings it closer to or equates it to the type of management carried out by digital platforms with service providers.

105 Op. cit., pp. 36 and 37.

different aspects of the labour relationship, such as the assignment of activities, performance assessment, salary and its components, professional classification and promotion, or access to continuous training, among others.

Working on digital labour platforms

Digital labour platforms are young and growing new business models based on cost efficiency, innovation and breadth of market. The work provided through these platforms is one of the most important new forms of employment to emerge in recent times[106]. The expansion of the platform economy has profound employment and social impacts that have been widely analysed and have led to legislative measures at EU and national level[107]. The coordination of work through algorithmic applications is inherent to the platform business which has been the first to implement it. But the effects of platform-delivered work, in terms of both opportunities and risks, go beyond those arising from algorithmic work management (primarily performance monitoring and evaluation).

The magnitude of this work was not easy to measure due to the heterogeneous nature of the platforms, the fact that the work provided can be not only physical and localised but also virtual or online, and the diversity of situations of the providers in terms of the time they spend, the regularity and the level of income they earn from this activity. Some field studies did provide a first approximation of its dimension and profile, notably the two COLLEEM (Collaborative Economy and Employment) Surveys in 2019 and 2020. However, it was recognised that these were still pilot surveys with important limitations[108]. Subsequently, progress has been made towards more precise definitions and measurement criteria. The main EU field study, carried out by the European Commission's JRC, has improved the statistical representativeness of the data used and with it the robustness of the results in the new AMP Work Survey (2023), which has succeeded the previous ones[109]. According to this source, 2.1 per cent of the working-age population in Spain (0.8 per cent in Germany) have ever earned income from providing services on digital labour platforms, the second most frequent income-generating activity on platforms. And for 1.4 per cent it represents the main form of employment (0.6 per cent in Germany)[110]. This proportion is undoubtedly small, also

106 International Labour Organization (ILO) (2021), "World Employment and Social Outlook. The role of digital labour platforms in transforming the world of work".

107 See the 2021 Report of the Economic and Social Council (ESC), Chapter II, "Challenges for the future. Digitalisation and work". The rationale and scope of the recent Directive 2024/2831 of 23rd October improving working conditions in platform work is dealt with in Chapter II of 2024 Report of the Economic and Social Council (ESC).

108 "The platformisation of work", cit. p. 43. A lack of representativeness of the sample was especially recognised, leading to a likely overestimation of platform work.

109 It is based on face-to-face interviews of a statistically representative sample of the overall working-age population in Spain and Germany conducted between late 2021 and early 2022.

110 It includes in the most generic form of platform work (broad prevalence) those individuals who report ever providing services, either online or in person, and earning income via platforms or apps. The definition of platform work as the main form of employment (adjusted prevalence, equivalent to a regular job

in Spain, but it may be considered relevant, above all because of its potential future growth in terms of the composition of this employment according to worker profiles, and especially because of two characteristics: a high proportion of young workers (mostly women) and with a higher level of education.

Digital platform work is part of the labour challenges of digitalising economies, including Spain[111]. Alongside the employment opportunities they have opened up, certain risks inherent to these jobs have also been highlighted, including the effects of algorithmic management, monitoring and assessment, and occupational health and safety protection, as well as difficulties in accessing social protection. How these and other issues are dealt with shall have very important consequences for these business models, for employment within them, and for the social protection of the persons providing such services, a problem that has recently been addressed in the Spanish and EU spheres, as will be seen.

The interaction of workers and robots

The robotisation of production processes is an essential contributing factor for technological innovation in many companies, especially in certain industry-related activities (i.e. assembly lines) and services (i.e. storage and distribution logistics). It is concentrated in robot-intensive industrial activities, although it has a wide scope for deployment in service activities. Unlike generative AI, it is not currently seen as having a disruptive effect on production or working conditions, as it has developed over a long time span. However, the use of industrial and service robots is likely to be boosted by the application of AI systems.

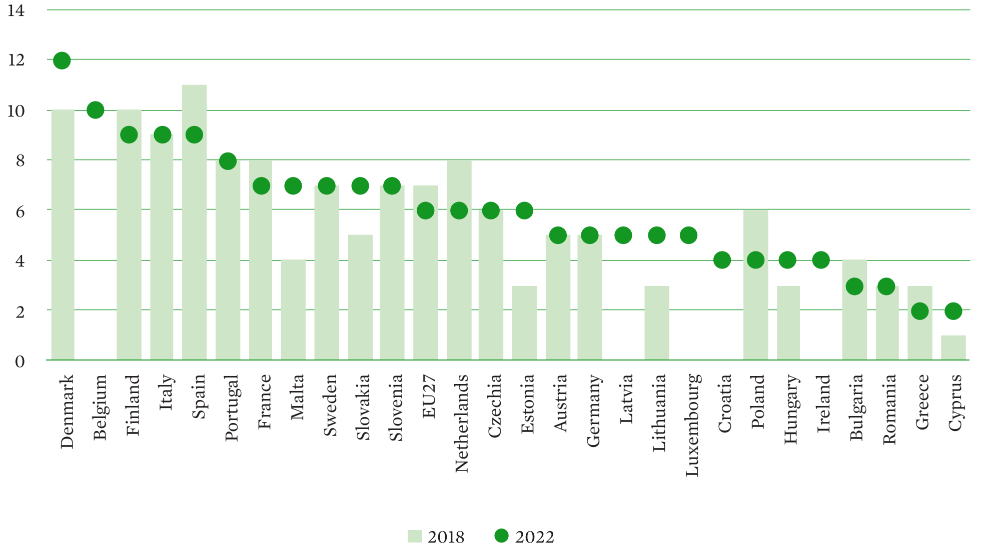
The most current information available (2022) indicates a level of robot use in European companies that, although significant, does not display clear signs of expansion, rather a certain contraction until that year for the EU-27 as a whole (Graph 18). Spain is one of the leading countries in the use of robots by companies, but their deployment also appears to have slowed down.

Nonetheless, the fact that it does not represent a radically new technological change should not make us lose sight of the benefits and risks involved. The incorporation of these technologies has had positive effects underpinning their implementation. Thus, for example, they have enabled the elimination of repetitive, arduous and hazardous tasks, introducing improvements in occupational health and safety, enhanced human capabilities, especially through the use of collaborative robots (cobots), and made it possible for companies and sectors to become more competitive in the production of certain goods and services.

in the conventional economy) includes all those who have earned income by providing services, online or in person, via platforms or applications, within the last month for at least 20 hours per week or have earned at least 50 per cent of their total income in this way.

111 See the 2021 Report of the Economic and Social Council (ESC), pp. 269-275.

GRAPH 18. USE OF ROBOTS BY EUROPEAN COMPANIES, 2018-2022 (Percentage)



Source: Eurostat.

However, they can also pose risks to the health and safety of workers. Considering only the use of robots interacting with people, the quantitative studies available though still limited, find a significant association between the use of this technology in production organisations and a series of indicators of working conditions. The strongest correlations observed point to increased work rates, increased exposure to surveillance, reduced autonomy, increased workload and increased likelihood of working alone as its main effects[112].

As in the use of other technologies, it is essential to balance the benefits and risks involved. In this regard, the above-mentioned analyses discuss workplace initiatives such as raising awareness of health and safety risks, consultation on the impact of stress at work, together with information and training to prevent and mitigate occupational risks.

GOVERNANCE OF CHANGE. THE ROLE OF SOCIAL DIALOGUE AND COLLECTIVE BARGAINING

As discussed above, the current wave of technological changes driven by digitalisation and the implementation of AI systems have had certain impacts on employment and occupations, on employability and active labour market policies, and on industrial relations and working conditions.

These technologies can help create more and better jobs, but they also pose new risks if they are not accompanied by the right policies and labour instruments. The

112 Eurofound (2024), "Human-robot interaction: What changes in the workplace?" Publications Office of the European Union, Luxembourg, pp. 16-17.

benefits of these changes will not come automatically, as maximising the opportunities and addressing the challenges they entail will require the shared adoption of strategies and measures, hence the focus on the governance of change is essential to ensure that these transitions take place for the benefit of all, workers and enterprises, maximising the benefits of digitalisation and ensuring a reliable use of AI systems in employment and industrial relations[113].

European and Spanish regulatory framework

With regard to the impact on labour relations and working conditions[114], a first level of action to be referred to is that corresponding to the heteronomous level of normative regulation, both at European and internal level. In the first of these, it is worth recalling the two most recent and important initiatives that have been approved, and which have already been mentioned[115]: firstly, Regulation (EU) 2024/1689 of 13 June laying down harmonised rules on Artificial Intelligence (Artificial Intelligence Act or AIA), as a rule of general scope[116], which is not specifically labour-related, but is also expressly applicable to labour relations in companies and self-employment; and secondly, Directive (EU) 2024/2831 of 23 October on improving working conditions in platform work, which establishes the minimum rights applicable to employment in these organisations.

AIA, which starts from the general premise of facilitating technological innovation and development, contains at the same time the overarching objective of achieving a people-centred use of AI, avoiding the risks of unregulated use. Thus, the contents of the AIA in the field of employment, labour management and self-employment make it possible to address certain uses of AI that may lead to invasive or discriminatory labour practices (directly or indirectly, through biases in the input data or in the design of automated decision-making algorithms), by means of certain prohibitions and through the classification of systems deployed in these areas and intended for certain personnel management activities as high-risk systems with the precautions and controls associated with this categorisation. An important space for intervention has thus been opened up, from the directly applicable Community regulation , to collective bargaining for “the establishment of a secure management of Artificial Intelligence in order to provide sureties and guarantees in favour of all”, workers and companies, and of the typical material areas of conventional regulation that may be the most affected[117].

113 The governance of the effects of digitalisation on work was addressed in the 2021 Report of the Economic and Social Council (ESC), pp. 281-293.
114 Policies on the effects on employment have been addressed in Section 2 of this main topic, on active labour market policies as a response to the challenges of technological change.
115 See Section 1.7.1. (Labour regulatory policy) of chapter 2, 2024 Report of the ESC.
116 Equivalent, in this sense, to what Regulation (EU) 2016/679, the General Data Protection Regulation (GDPR), represented at the time and in its scope of application.
117 J. Cruz Villalón (2024): “La intervención de la negociación colectiva en el despliegue de la inteligencia artificial”. Boletín de la Comisión Consultiva Nacional de Convenios Colectivos, 90, 2024.

The AIA also contains a provision requiring employers who deploy a high-risk AI system in the workplace, to inform workers' representatives and the workers concerned that they will be exposed to such a system, prior to its commissioning or use.

The Directive on improving working conditions in platform work limits its subject matter and scope of application to work in such organisational and business models. Within this area it contains a comprehensive and labour-specific regulation of algorithmic management (automated monitoring and decision-making systems), among other labour-related measures. Thus, it addresses rules regarding transparency and human supervision, provides for assessments (involving workers' representatives) of the impact of automated decisions on people performing platform work, including, where appropriate, on their working conditions and equal treatment at work (anti-bias assessments), human decision-making on certain elements of the contractual relationship, human review, health and safety regulations, and obligations to inform and consult workers' representatives, among other provisions.

These European regulations, the AI Regulation and the Platform Work Directive, have expanded the nascent regulatory framework in Spain for the use of these technologies, already provided for in three main regulation dealing, respectively, with the guarantee of digital rights in the labour sphere, within the more general framework of the data protection regulation, and specifically the right to digital disconnection; the regulation of on remote working; and the regulation of delivery services via digital platforms, which incorporated a presumption of labour rights and a right of information of workers' representatives regarding algorithmic transparency[118]. These regulations implied an express recognition of the effects of digitalisation on the workplace and the need to address them; but, additionally, in the case of remote working and platform-based delivery activity, these regulations responded to tripartite social agreements that thus placed the labour effects of digitalisation on the social dialogue agenda as a framework for addressing them, in line with Europe-wide social dialogue. It is also important to remember that transparency in the algorithmic management of work, as a right of information of the workers' representative, although regulated in the Act on distribution on digital platforms, extends to all companies and activities, not only to the former[119].

European social dialogue

Beyond the above-mentioned regulatory policies, it is essential to address transitions and changes through the driv-

118 Organic Act 3/2018, of 5th December, on Personal Data Protection and Guarantee of Digital Rights; Act 10/2021, of 9th July, on Remote Working; and Act 12/2021, of 28th September, amending the consolidated text of the Workers' Statute to guarantee the labour rights of persons engaged in delivery on digital platforms.

119 This right of the workers' representative is stated in Section 4 (rights to information) of Article 64 of the Workers' Statute: the right of the workers' committee to "be informed by the company of the parameters, rules and instructions on which algorithms or Artificial Intelligence systems are based that affect decision-making and which may have an impact on working conditions, access to and maintenance of employment, including profiling".

ing role of social dialogue, both at EU and national level, and through labour relation instruments, especially via the role of collective bargaining in labour organisation and adaptation.

There is broad institutional consensus in the EU on the importance of social dialogue as a central tool for the governance of technological change, digitalisation and AI, and its impacts on the world of work, on the basis of its key role in anticipating and managing structural changes[120].

The European Economic and Social Committee (EESC) has contributed to the governance of digitalisation and AI[121], pointing out that the processes of change brought about by new technologies, Artificial Intelligence and Big Data must take place within a framework of fruitful social dialogue[122], and more specifically on the governance of AI in relation to employment policies and the labour market, stressing once again the significant role of social dialogue in this field[123].

European social partners reached a fundamental consensus in the European Framework Agreement on Digitalisation (EFAD) which they signed in 2020[124]. The overall objective of the EFAD was to achieve a consensual transition to a successful integration of digital technologies in the workplace, maximising opportunities and preventing and minimising the risks of these processes for both employers and workers, ensuring the best outcomes for both parties. To this end, it focused on a number of areas (occupational content and skills, working conditions, labour relations and work organisation) and themes (digital skills and securing employment, modalities of connecting and disconnecting, Artificial Intelligence and guaranteeing the human control principle, respect for human dignity and surveillance). As an autonomous Agreement arising from negotiations between European social partner organisations, the EFAD provided an important instrument to address very incipient but forward-looking structural changes of the time, such as the use of AI systems in the workplace.

The EFAD signatory organisations undertook to promote and implement tools and measures at the necessary level (national, sectoral and/or company level) in accordance

120 Communication from the European Commission on the "European Pillar of Social Rights Action Plan", COM (2021) 102 final. The Communication from the European Commission on "Strengthening social dialogue in the European Union: harnessing its full potential for managing fair transitions", COM (2023) 40 final, is also highly relevant. The new forms of work organisation enabled by digitalisation and their effects on employment have been in the sights of European social partners for a long time. Thus, in 2026, the European social partners (BusinessEurope, CEEP, ETUC and UEAPME) issued a joint declaration on digitalisation, in which they expressed a shared view of the importance of the challenges posed by digitalisation, and the need to address them by implementing public policies at both EU and Member State level, and through agreements between trade unions and employers' organisations.

121 EESC Opinion on "Digital identity, data sovereignty and the path towards a just digital transition for citizens living in the information society" (2022/C773/01).

122 EESC Opinion on "Fostering an entrepreneurship and innovation friendly single market – promoting new business models to meet societal challenges and transitions" (2019/C 353/02).

123 EESC Opinion on "Pro-worker AI: levers for harnessing the potential and mitigating the risks of AI in connection with employment and labour market policies" (C/2025/1185).

124 European Trade Union Confederation, BusinessEurope, SMEunited and CEEP: European Social Partners Framework Agreement on Digitalisation, June 2020.

FIGURE 15. RECENT CONTRIBUTIONS OF THE EESC ON AI GOVERNANCE IN RELATION TO EMPLOYMENT AND LABOUR MARKET POLICIES

- The positive or negative direction of change brought about by AI developments is not an open and shut question, but depends on policy-makers' choices in formulating ambitious and effective policies and regulatory frameworks that favour social progress, inclusion, equality, economic prosperity, sustainability, business continuity and resilience, the creation of decent jobs, respect for democratic institutions and workers' rights. Social dialogue plays a key role in this regard.
- Social dialogue and worker participation play a crucial role in preserving the fundamental rights of workers and promoting reliable AI in the world of work. Indeed, increasing the participation of workers and their representatives is one of the mechanisms to minimise the risks and harmful effects of AI systems.
- Legislative – or any other – initiatives aimed at adapting existing regulations must address gaps in the protection of workers' rights at work and ensure that people remain in control in all interactions between man and machine[125].
- The authorities must put in place initiatives for the development of workers' skills in order to ensure that Artificial Intelligence systems enhance human performance rather than replace it.
- In order to avoid fragmentation of existing Member State initiatives and to ensure a level playing field in the single market, the EESC calls for an effective social dialogue on the use of AI systems on the basis of an ad hoc EU legal instrument to be shaped.
- The EESC calls on the European AI Office to maintain close cooperation with European cross-sectoral social partners in order to ensure that the role of social dialogue is adequately reflected in its forthcoming guidelines and to provide clarification on all AI systems.

Source: EESC Opinion on "Pro-worker AI: levers for harnessing the potential and mitigating the risks of AI in connection with employment and labour market policies" (C/2025/1185).

with the specific procedures and practices of the social partners at national level. In Spain, the signatory organisations of the V Agreement for Employment and Collective Bargaining (V AENC): CCOO, UGT, CEOE and CEPYME, made it a priority to adapt it to each bargaining area "assuming the shared commitment between the European cross-sectoral social partners to face the common challenge of the digital transformation in the world of work", for which they established a series of criteria for collective agreements[126].

125 The EESC has been insisting that it is essential for humans to have the final say and to be able to fully control and govern decision-making processes with regard to the evolution of machines (AI). See, inter alia, EESC Opinion on "Artificial Intelligence – The consequences of artificial intelligence on the (digital) single market, production, consumption, employment and society" (2017/C 288/01).

126 The EFAD provided for an autonomous mechanism for the implementation and verification of compliance, together with an oversight procedure by the European Social Dialogue Committee, however, there is no information available on its results at national, sectoral and/or company level.

One area of especial relevance for the governance of change is social dialogue across all European sectors[127]. European sectoral social partners have been focusing on the governance of digitalisation, and more recently on AI governance, pointing out that there is still ample room for progress in this area. A number of joint instruments on digitalisation have been agreed upon in the last decade, and have addressed certain work-related aspects of AI in the sectors of central government, regional and local government, cleaning, banking, commerce, metal, pulp and paper, chemicals, insurance and telecommunications activities, among others. The most recent include the Joint Declaration on Employment Aspects of Artificial Intelligence by the European Social Partners in the Banking Sector (2024), the European Framework Agreement of the Social Dialogue Committee of Central Administrations on Digitisation (2022), or the Joint Recommendations on Digital Transformation in the Workplace for the European Chemicals, Pharmaceuticals, Rubber and Plastics Sectors (Chemical Industry, 2019)[128].

In the field of European social dialogue, and within this context, it is therefore important to make further progress on instruments to ensure the correct implementation of new digital technologies in the workplace, guaranteeing equal opportunities and treatment, good working conditions, correct work organisation and the prevention of health risks, as well as ensuring human control of Artificial Intelligence tools, and promoting social dialogue at different levels. The EECS' request to the European AI Office to maintain close cooperation with European sectoral social partners is relevant to this objective[129].

Social dialogue and collective bargaining in Spain

The field of digitalisation and its effects on work and labour relations has important precedents in the tripartite social dialogue between social partners, the most representative national trade union and employer organisations, and the government, such as the Agreement on Remote Working (2020) and the Agreement on Guaranteeing the Employment Rights of Workers on Digital Delivery Platforms (2021)[130]. Such agreements have had a significance beyond their regulatory content as they have meant addressing by means of social dialogue the opportunities and challenges of a transformation process such as digitalisation, with relevant potential effects on work as it has been known until recently.

Two fundamental instruments of social dialogue to address the effects of these changes in Spain should be highlighted: the Spanish Strategy for Safety and Health

127 The European Commission has reminded that it covers more than 80 per cent of the EU workforce through the 43 sectoral social dialogue committees. Communication from the Commission on "Strengthening social dialogue in the European Union: harnessing its full potential for managing fair transitions", COM (2023) 40 final, cit.

128 European Commission, Social Dialogue texts database.

129 EESC Opinion on "Pro-worker AI (...)", cit.

130 See 2020 and 2021 Reports on the socio-economic and employment situation of the Economic and Social Council (ESC).

FIGURE 16. 5TH AENC CRITERIA ON DIGITAL TRANSITION AND AI

Technological and digital transition

The implementation of digital technologies brings **clear benefits** for both companies and workers (...) but, at the same time, **it also entails challenges** due to its impact on working conditions.

It is essential that sectoral and company collective agreements incorporate measures to address these challenges in order to **promote a fair, inclusive and beneficial transition** for all parties, (...), adapting these measures to the realities of each sector, activity and company and anticipating their impact on workplaces.

Sectoral and company collective agreements must **promote and encourage digital transformation in the workplace** within the framework of **participatory processes** and we believe it is appropriate for them to establish **specific procedures for prior information to the legal representatives of workers**, of business digitalisation projects and their effects on employment, working conditions and the training and professional adaptation needs of the workforce, with a commitment to **continuous training for the improvement of digital skills of workers** in order to facilitate this transition in the company.

Collective bargaining will promote an **equal opportunities policy** to ensure that digital technology is beneficial for all workers, **overcoming the age gap**.

Positive action measures to avoid the digital divide between women and men will be promoted, especially with regard to advanced skills, guaranteeing the necessary training processes to adapt to changes in the workplace as a result of the company's digital transformations, in accordance with the criteria established by labour regulations.

Artificial Intelligence (AI) and guaranteeing the principle of human control and the right to information about algorithms

AI will progressively have a significant impact on the world of work and, if not used correctly and transparently, could lead to biased or discriminatory decisions regarding labour relations.

Collective bargaining has a key role to play in establishing criteria to ensure the proper use of AI and on the implementation of the duty of regular reporting to workers' representatives.

The deployment of AI systems in enterprises should **follow the principle of human control** over AI and be secure and transparent.

Companies shall provide the legal representatives of **workers with transparent and understandable** information on AI-based human resources procedures (recruitment, assessment, promotion and termination) and **ensure that there is no prejudice or discrimination**.

The deployment of **AI systems in public administrations** must also follow the principle of human control and be secure and transparent.

Source: 5th AENC.

at Work (EESST 2023-2027), in the field of occupational health and risk prevention, and the Labour and Collective Bargaining Agreement (5th AENC). The EESST 2023-2027 is the instrument addressing occupational safety and health risks for workers on a general basis in the coming years but, at the same time, it should also serve to address emerging risks in a world of work subject to profound changes such as those arising from the digital transformation of companies and work organisation, thereby achieving safe and healthy working environments also in relation to technological changes, digitalisation and AI. The 5th AENC contains criteria and recommendations in various areas, including those related to technological, digital and ecological transformations, and in relation to remote or teleworking[131].

The governance of technological change at work through collective bargaining has been a field with limited development. Even today, the statistics on collective bargaining agreements show a low percentage of agreements and workers with clauses on the implementation of new technologies (6.7 and 12.5 per cent respectively). While the clauses on technology and employment were on the rise, especially in areas such as the right to digital disconnection, there was little deployment and the approaches were rather proclamatory, unsystematic and not well planned[132]. In recent years, clauses such as the right to disconnect and remote working have become increasingly prevalent, as they have been regulated for somewhat longer[133]. Conventional regulation in more advanced and timely issues such as AI and algorithmic management still appears to be scarce, but this may change in the short term due to their penetration in work structures, the consensus of social partners regarding its necessity in the 5th AENC, and the effect of recent European regulations, which are opening up spaces for collective bargaining[134]. These, for their part, already offer some significant and good examples of negotiation in Spain and other EU Member States[135], especially in different sectors, which may have a teaching or a knock-on effect on other areas of negotiation.

131 In order to develop, in the collective bargaining process, all elements whose normative regulation, originating in the tripartite social dialogue agreement reached in 2020, refers to it. It also includes a novel commitment to establishing shared guidelines for the effective implementation of the right to digital disconnection based on collective autonomy.

132 J.J. Fernández Domínguez (dir.) et al., Nuevos escenarios y nuevos contenidos de la negociación colectiva, MITES, Madrid, 2020.

133 The Social Economy Portal (ECC) of the Ministry of Labour and Social Economy (MTES) displays figures of 18% and 38%, respectively, of collective bargaining agreements and employees with clauses regulating remote working conditions.

134 J. Cruz Villalón (2024): "La intervención de la negociación colectiva en el despliegue de la inteligencia artificial", cit.

135 H. Álvarez Cuesta, "Experiencias convencionales de regulación del impacto laboral de la inteligencia artificial y su uso con fines de control", Trabajo y Derecho, 19, June 2024. D. Pérez del Prado, "Negociación colectiva e inteligencia artificial", Foro de Labos Blog, 16-01-2025 (https://www.elforodelabos.es/2025/01/negociacion-colectiva-e-inteligencia-artificial/).

FIGURE 17. LABOUR IMPACTS OF CLIMATE CHANGE

Labour impacts of technological change

The impact of technological change on employment may be quantitative, qualitative or a combination of both. Employment may also be affected in terms of changing profiles within jobs and occupations, and their related skill requirements. These same factors may also affect changes in pay and in the range of aspects that typically define job quality. How technology changes labour tasks and the work environment has important implications for job quality and ultimately for the well-being of workers.

EMPLOYMENT IMPACTS

Net positive impact of technological change in the long term.

In general, the three Industrial Revolutions prior to this one are estimated to have maintained (and even increased) employment levels.

Neutral impact of automation technologies prior to generative AI.

There is little evidence of a significant drop in overall employment in labour markets as a result of automation in the period immediately preceding the onset of generative AI. Similarly, the few studies that have already addressed the impact of AI on aggregate employment have found little to no effect on employment.

Increased reach and impact with the development of generative AI.

While previous waves of innovation had a greater impact on less educated workforces, recent developments mean that AI is also impacting non-routine cognitive tasks, extending its reach to skilled profiles. The wider reach and ease access of generative AI technologies suggest a more widespread impact on the labour market than previous waves of AI.

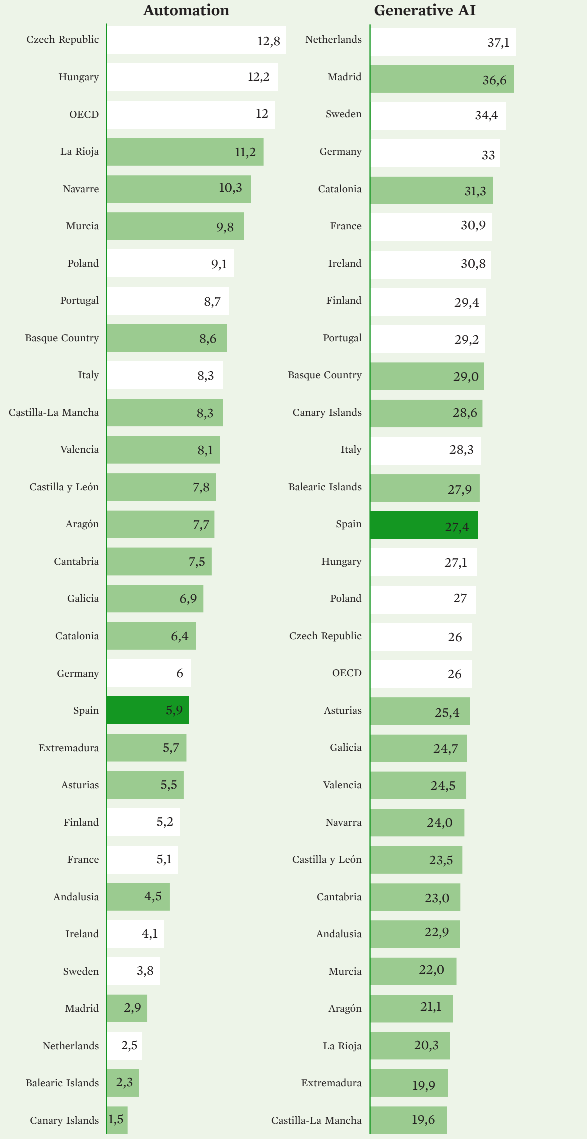
Increased exposure to AI does not imply job displacement.

It should correlate primarily with productivity, as exposure estimates measure the proportion of tasks that may be completed more quickly with the help of generative AI.

Technological change can lead to inequalities and difficult transitions.

The new jobs that are created are typically in different sectors, often in different regions, and require different skills than the jobs that were lost, which has contributed to increasing disparities between different groups of people and territories.

EMPLOYMENT EXPOSED TO TECHNOLOGICAL CHANGE, 2022



Source: OECD, 2024.

FIGURE 17. LABOUR IMPACTS OF TECHNOLOGICAL CHANGE (*continuation*)

Active labour market policies as a response to the challenges of technological change

Fewer professions use AI in Spain than in the rest of the neighbouring countries surveyed. Moreover, the pace of AI adoption is also somewhat slower. Despite this, around half of all workers report a need for training in this area. Therefore, active labour market policies should promote actions to enhance the employability of all workers, leaving no one behind, and to respond to production requirements, training for a responsible design and use of AI that avoids harming workers, companies or third parties. To this end, active labour market policies have the opportunity to integrate the use of AI to increase the efficiency and effectiveness of their actions:

POTENTIAL

Profiling of job seekers:

- characterisation and segmentation of jobseekers
- calculation of the probability of employment based on individual data and characteristics of the jobseeker.

Personalisation of services

- matching jobseekers to interventions, and active labour market policies programmes according to their requirements.
- Designing personalised training programmes adapted to territorial and personal diversity.
- integration of external databases (on socio-economic conditions, on performance in previous work experiences, results in previous programmes, etc.) for further fine-tuning of interventions.
- determination of conditions to be fulfilled for accessing training opportunities, hiring subsidies, etc.
- identifying employment opportunities for specific profiles or additional difficulties for labour market insertion.
- information and job counselling(chatbots)
- detection of irregularities in the provision of services and interventions

Improved* matching *between labour supply and demand:

- creation and enhancement of profiles by analysing resumes, detecting and enhancing key skills or experiences.
- optimisation of job offers (use of keywords that promote and focus the search among targeted candidates; use of terms that promote diversity, etc.).
- detection of training gaps and matching with available training offers.
- matching competences or skills of jobseekers with vacancies, including future vacancies resulting from prospective labour market analysis.

Market research and forecasting:

- greater level of information and variables, which contributes to greater equality in decision-making.
- better information and predictability of employment needs in the market, specific sectors, etc.
- support for workers' mobility on the basis of better information on vacancies. This information may be extended to source markets.
- prediction of events with impact on employment: probability of unemployment, risk of company closures.

Programme evaluation:

- analysis of the impact of programmes and services.
- identification of best practices based on impact.
- estimation of the probability of successful scaling up.

Networking:

- combining the activity of employment services with equivalent institutions and other sectors at regional or municipal levels.

CHALLENGES

Lack of robustness of AI tools

- biases in algorithm training data, which may reproduce patterns of discrimination.
- insufficient representativeness of data samples for certain groups of workers or categories of information.

Risks of discrimination and exclusion

- technological gaps (access or lack of skills) in certain territories.
- access barriers for persons with disabilities.
- discrimination is less intuitive and more difficult to detect if it originates in the system's design or behaviour.
- impossibility of detecting intangible or non-objectifiable elements of jobseekers and companies.

Transparency and explainability of decisions

- the need to inform job seekers that their profiles are being analysed by AI.
- opacity: AI tools can be a "black box", when it is not possible to explain decisions and results due to a lack of knowledge of standards and criteria.
- difficulties in attributing results to certain variables, determining the weights of each factor, etc.

Privacy

- the use of data from the internet(web scraping) raises doubts about consent in data transfers.
- the need to ensure the security of systems with regard to the use of personal and sensitive information.

Complementarity of AI with human control in Public Employment Services

- AI decisions are an additional element of decision and recommendation.
- need to train staff in data analytics to optimise the use of AI, interpret algorithms, etc.

FIGURE 17. LABOUR IMPACTS OF TECHNOLOGICAL CHANGE (*continuation*)

Technological change and industrial relations. The role of social dialogue and collective bargaining

The increasing integration of new technological tools in companies has significant positive, production and organisational effects for companies and workers, but at the same time, it poses new challenges and risks for companies that must be addressed. Alongside the widespread use of digital devices at work and the digital monitoring they enable, as well as processes such as automation-robotisation, more recently algorithmic management of work is making inroads, initially in digital platform work, but increasingly extending to conventional employment. Although information in this regard is still limited, available sources point to a varying degree of prevalence of these tools in companies in Spain, as well as the main effects and challenges they pose.

Prevalence of technologies, effects and challenges

1. Use of devices and digital monitoring	***Prevalence*** Widespread and increasing use of desktops, laptops, tablets, smartphones and other mobile devices in European enterprises (Fourth ESENER, 2024). 65% of workers in Spain use these devices (JRC - European Commission), which are often used to monitor and supervise work performance.
	Main effects *Positives:* improved tasks and access to information, elimination of long, tedious and repetitive processes, greater time flexibility and autonomy, improved performance. Risks: new risks to health and safety at work (musculoskeletal disorders, repetitive movements, increased intensity, information overload, data collection).
	Main challenges Make progress in improving the assessment of occupational risks arising from digitalisation; increase the number of companies that consult with the Legal Representation of Workers (RLT) on the potential impact of digital technology on occupational health and safety; implement transparency and information policies in companies for workers regarding its use.
2. Algorithmic Management in the Workplace (AMW)	***Prevalence*** In Spain, as in other advanced economies, a significant proportion of companies and workers use some form of work management system (automated management and organisation).
	Main effects *Positive:* improved work organisation, greater consistency in decision-making, predictability of instructions and neutralisation of possible human biases. Workplace data collection and analytics, combined with the use of AI models, can enable organisational innovations and productivity improvements. *Risks:* A.M. is associated with complex activities and detailed procedures, reduced flexibility and autonomy of workers, more monotonous jobs and increased stress at work; these features are accentuated when the A.M. is more intense, “strong platformisation” of work, which is observed in 6.1% of the employed population in Spain.
	Main challenges Ensuring transparency, explainability and human control in the algorithms applied in the automated management and organisation of work; avoiding potentially discriminatory biases due to different personal circumstances in the elements of the employment relationship (activity assignment, performance appraisal, salary and its components, grading and career advancement, access to further training, etc.).

FIGURE 17. LABOUR IMPACTS OF TECHNOLOGICAL CHANGE (*continuation*)

	Governance of change
1. Regulatory level	In addition to the regulations already in force in Spain in these matters, two recently approved Community initiatives are worth mentioning. The EU AI Law. It pursues the cross-industry objective of achieving a human-centred use of AI. In the area of employment, labour management and self-employment, it contains certain prohibitions, and systems deployed in these areas intended for certain personnel management activities are classified as high-risk systems with consequent obligations and controls. The EU Platform Work Directive. It addresses rules regarding transparency and human supervision, provides for assessments (involving workers' representatives) of the impact of automated decisions on people performing platform work, including, where appropriate, on their working conditions and equal treatment at work (anti-bias assessments) and includes human decision-making on certain elements of the contractual relationship, human review, health and safety regulations, and obligations to inform and consult workers' representatives, among other provisions.
2. Social dialogue	In addition to policy measures, it is essential to address transitions and change through the driving role of social dialogue, both at European Union (EU) and national level. There is broad institutional consensus in the EU on the importance of social dialogue as a central tool for the governance of technological change, digitalisation and AI, and its impacts on the world of work. European social partners share this fundamental consensus. An example of this is the European Framework Agreement on Digitalisation signed in 2020. The Framework Agreement was an important tool to address future structural changes such as the use of AI systems in the workplace. Another especially important area in the governance of technological change is the European sectoral social dialogue. Two fundamental instruments of social dialogue to address the effects of these changes in Spain should be highlighted: the Spanish Strategy for Safety and Health at Work (EESST 2023-2027), in the field of occupational health and risk prevention, and the Labour and Collective Bargaining Agreement (V AENC). The 5th AENC (2023-2025) contains criteria and recommendations in various areas, including, for these purposes, those related to the technological and digital transition, and AI.
3. Collective bargaining	Regulations in the collective bargaining of issues such as AI and algorithmic management still appears to be scarce, but this may change in the short term due to their penetration in work structures, the consensus of social partners on their necessity in the V AENC, and the effect of recent European regulations, which are opening spaces for collective bargaining. There are already some significant and good examples of negotiation practices in Spain and other EU Member States, particularly in different sectors, which may have a teaching or a knock-on effect on other areas of negotiation.

CONCLUSION:

Employment in Spain is unlikely to be affected extremely negatively due to AI, but it will face a process of transformation in the nature of work. The key will be to adapt the workforce to new technologies. Regional and personal differences in exposure to GenAI indicate that training and adaptation policies should take into account territorial and personal diversity, with especial focus on areas and individuals most vulnerable to technological change. With the right policies, Spain can harness AI to foster inclusive and sustainable economic development, preparing its citizens for the jobs of the future. The benefits and risks of technological transformations at work are not pre-determined. Securing opportunities and addressing challenges means adopting strategies and measures through a shared approach. It is therefore essential to focus on the governance of change to ensure that these transitions take place for the benefit of all, workers as well as companies, maximising the benefits of digitalisation and ensuring the reliable use of AI systems in employment and industrial relations.

Source: Authors' own.

SOCIAL IMPACTS OF ARTIFICIAL INTELLIGENCE

1. Humanistic digitalisation and Artificial Intelligence

The development of Artificial Intelligence (AI) is proving to be one of the disruptive technologies with the greatest capacity for social transformation, beyond the new dynamics it is bringing to the economy and employment, as mentioned in previous sections. AI is increasingly behind decisions that determine people's living conditions and rights, accessibility and quality of products and services on the market, as well as the management of important infrastructures, benefits and services that determine people's well-being and quality of life. It is therefore a historic opportunity to improve social welfare, health, public benefits and services, as well as the sustainability of the planet and the achievement of the goals of the 2030 Agenda.

Together with the above, new technologies in digitalisation and especially the massive processing of data and its use by means of algorithms is bringing about a profound change in how citizens interact with companies and public administrations; on numerous occasions providing important opportunities for improving care but also entailing challenges from the perspective of fundamental rights such as personal freedom, privacy, freedom of expression and information, the right to a fair trial or the prohibition of discrimination (Figure 18).

Ambivalent public attitudes towards the social impacts of AI

The most recent studies reveal Spanish citizens' ambivalence regarding Artificial Intelligence, marked by contrasting expectations depending on the areas of application. Thus, according to a recent study by the Centre for Sociological Research (CIS),[136] interest (68.3 per cent), uncertainty (67.2 per cent) and concern (58.4 per cent) are the three most prevalent sentiments generated by technological advances in people. 66 percent agree that AI can bring many benefits to the field of health and medicine. But 53.4 per cent believe that it can harm culture, values and ways of life, and 51.3 per cent feel the same about the protection of people's rights. Additionally, 86.9 per cent "strongly or somewhat agree" that AI can be used to spread misinformation and hoaxes; 80.6 per cent believe it can facilitate crime or illegal acts, and 72.2 per cent say it can lead to greater global inequality.

136 CIS, Study 3495 *Artificial Intelligence*. February 2025.

FIGURE 18. SOCIAL IMPACT AND ENVIRONMENTAL SUSTAINABILITY OF AI

	Social welfare	Environmental sustainability
Benefits and opportunities	**Accessibility and equity:** Improving access to essential benefits and services such as Social Security, education, healthcare and social benefits, optimising resources and personalising care. **Improvements in health, healthcare and medical research:** AI applications for the early diagnosis of diseases, development of personalised treatments and automation of administrative processes in hospitals. **Innovation in education:** Adapting learning to the needs of students, making available new pedagogical tools and facilitating the inclusion of people with disabilities. **Efficiency in public services:** Optimising the management of government infrastructure and services, improving crisis and emergency response.	**Optimisation of energy consumption:** AI can improve energy efficiency in industries, smart cities and power grids, reducing their environmental impact. **Mitigation of climate change:** It enables the monitoring and prediction of weather patterns, facilitating strategies to reduce carbon emissions and improve natural resource management. **Sustainable agriculture:** AI-based technologies optimise the use of water, fertilisers and pesticides, contributing to more sustainable production. **Circular economy:** AI improves the recycling and reuse of materials, promoting more sustainable production models.
Challenges and risks	**Inequality and the digital divide:** Unequal access to technology can deepen socio-economic differences and exclude certain population groups. **Impact on employment:** The automation of tasks may replace traditional jobs, creating job uncertainty and changes in the demand for skills. **Privacy risks:** The mass collection of personal data can violate citizens' privacy and facilitate mass surveillance. **Disinformation and manipulation:** AI systems can be used to spread false information or influence public opinion in unethical ways.	**AI carbon footprint:** Data centres and high-performance computing consume large amounts of energy, contributing to CO2 emissions. **Resource extraction:** The production of AI hardware requires critical materials, which can have negative impacts on ecosystems and local communities. **E-waste:** Rapid technological progress leads to the premature obsolescence of devices, thus increasing the amount of e-waste.

Source: *Ethical guidelines for trustworthy AI*, High Level Expert Group on Artificial Intelligence, set up by the European Commission in June 2018. Published on 8 April 2019.

As for certain human tasks that could eventually be replaced by robots, one of the most uncomfortable for Spaniards would be to undergo a medical operation performed by a robot, or to talk to an Artificial Intelligence, for example, in an information or customer service centre. Thus almost the entire sample (92.7 per cent) "strongly or somewhat agree" that companies and organisations should report when they use artificial instead of human intelligence, while 93.4 per cent "strongly or somewhat agree" that Artificial Intelligence programming and training should be regulated. There is therefore a certain tension between the transformative potential attributed to this technology and the caution surrounding its consequences, along with a clear appeal to public authorities regarding the need to guarantee certain rights.

Meanwhile, within the context of the main international organisations and especially within the EU, the realisation of the need to safeguard these rights has given rise

FIGURE 19. KEY PRINCIPLES FOR THE BENEFICIAL USE OF AI FOR HUMANITY

- Transparency and accountability: Decisions made by AI systems must be understandable, explainable and subject to human oversight.
- Justice and inclusion, avoiding discrimination, making the benefits of AI accessible to all, and promoting cultural diversity.
- Environmental sustainability: AI systems should be designed to protect the environment and support the Sustainable Development Goals.
- Data privacy and governance: Personal data protection must be ensured throughout the lifecycle of AI systems.
- Security and risk mitigation: Priority is given to the development of secure systems that minimise risks to people and the environment.
- Ethical assessment: Countries must implement methodologies to assess the ethical impact of AI in their specific contexts.
- Education and raising awareness: Digital and ethical literacy in AI should be promoted to increase public understanding of its responsible use.
- International collaboration: To promote global cooperation in research, development and ethical implementation of AI.
- Human oversight: The ultimate responsibility must rest with individuals, ensuring that technologies do not replace human accountability.

Source: UNESCO Recommendation on the Ethics of Artificial Intelligence, 2021.

to various attempts at regulation. Thus, the principle of human centrality has gradually found its way into how international organisations approach the development and application of Artificial Intelligence.

1.1. THE NEED FOR SAFE, RELIABLE AND PERSON-CENTRED AI

Within the UN, the UNESCO Recommendation on the Ethics of Artificial Intelligence of 2021 has already set out a number of key principles to ensure the development and use of AI for the benefit of humanity, while minimising its risks.

More recently, the Resolution on Artificial Intelligence (2024)[137] states that "the same rights that people have offline must also be protected online, including throughout the lifecycle of Artificial Intelligence systems". The resolution urges States to refrain from using Artificial Intelligence systems that cannot operate in accordance with international human rights standards or put them at risk. It also encourages States, the private sector, civil society, research organisations and the media to develop regulatory and governance approaches and frameworks for the safe and reliable use of AI (Figure

137 Resolution "Seizing the opportunities of safe, secure and trustworthy artificial intelligence systems for sustainable development" of 21 March 2024. The draft resolution, led by the US government ahead of the November 2024 elections, was adopted by acclamation by the UN General Assembly with the support or "co-sponsorship" of more than 120 member states.

FIGURE 20. AI AND HUMAN-CENTRIC PERSPECTIVES: SECURE AND RELIABLE SYSTEMS

Secure and reliable AI systems: Artificial Intelligence systems in the non-military domain whose life cycle includes the stages of pre-design, design, development, evaluation, testing, deployment, use, sale, acquisition, operation and decommissioning, and have the following characteristics:
They are people-centred, reliable, explainable, ethical and inclusive, fully respect the promotion and protection of human rights and international law, maintain confidentiality, are geared towards sustainable development and are accountable – they have the potential to accelerate and enable progress for the achievement of the 17 Sustainable Development Goals and sustainable development in all three dimensions – economic, social and environmental – in a balanced and integrated manner, promoting digital transformation, peace, bridging digital divides between and within countries, promote and protect the enjoyment of human rights and fundamental freedoms for all, keeping the individual at the centre.

Source: Resolution 78/265, adopted by the United Nations General Assembly on 21 March 2024. "Seizing the opportunities of safe, secure and trustworthy artificial intelligence systems for sustainable development".

20). It also recognises the potential of AI systems to accelerate and enable progress towards achieving the 17 Sustainable Development Goals, avoiding the inequality that arises from the technology gap between countries and between people within countries.

Among the most recent initiatives, the OECD[138] has been working to provide a global stance on the use of AI to support different countries, through minimum principles that, although not legally binding, are intended to serve as a guide for these systems.

The EU, an advanced environment for the recognition of digital rights linked to AI

The European Union is one of the most advanced regions in the world in the recognition of digital rights and especially those linked to the development of AI, as a combination of technologies that brings together data, algorithms and computing power. Although the European Personal Data Protection Regulation (GDPR) already marked a significant step forward in the protection of personal data through AI systems, the EU's concerns about the ethical implications of the use of this technology were more explicitly expressed in the 2019 report of the Independent High Level Expert Group on Artificial Intelligence, then in the 2020 White Paper on Artificial Intelligence[139], and later in the European Declaration on Digital Rights and Principles for the Digital Decade[140]. In turn, the Ibero-American Charter on Artificial Intelligence in Civil Service,

138 OECD, Recommendation on Artificial Intelligence, 2024. See also, Artificial Intelligence Policy Observatory. https://oecd.ai/en/wonk

139 European Commission, *White Paper on Artificial Intelligence: a European approach to excellence and trust,* Brussels, 19.2.2020 COM (2020) 65 final.

140 European Declaration on Digital Rights and Principles for the Digital Decade of the European Parliament, the Council and the Commission (2023/C 23/01).

which was approved in November 2023, suggests criteria for AI implementation in public administration from a human-centred, ethical, transparent and reliable approach.

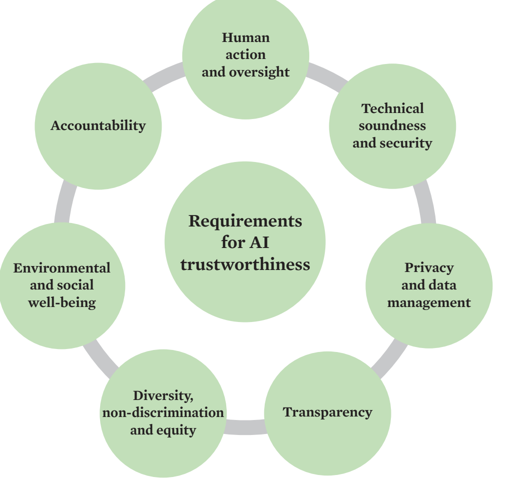
More precisely, a number of risks inherent to the use of AI has already been identified in 2019[141], setting the boundaries for the development, deployment and use of trustworthy AI. The reliability of AI relies is based on three components that must be satisfied throughout the system's life cycle: a) AI must be lawful, i.e. it must comply with all applicable laws and regulations; b) it must be ethical, so as to ensure respect for ethical principles and values; and c) it must be robust, both technically and socially (Figure 21).

FIGURE 21. ETHICAL GUIDELINES FOR ROBUST AND TRUSTWORTHY AI

Ethical principles and related values

Respect for human autonomy, prevention of harm, fairness and explainability.
Special attention to situations affecting the most vulnerable groups, such as children, people with disabilities and others who have been historically disadvantaged or at risk of exclusion, as well as situations characterised by power or information imbalances.
It should be recognised that, while AI can bring substantial benefits to individuals and society, AI systems bear certain risks and may have negative impacts, some of which are difficult to foresee, identify or measure (e.g. on democracy, the rule of law, distributive justice or the human mind itself).
Take appropriate and proportionate measures to mitigate these risks where necessary.

Requirements for trustworthiness



Source: European Commission, Independent High Level Expert Group on Artificial Intelligence, *Ethical guidelines for trustworthy AI*, 2019.

141 Independent High Level Expert Group on Artificial Intelligence, created by the European Commission in June 2018. *Ethical guidelines for trustworthy AI*. Brussels, April 2019.

In order to ensure compliance with these requirements, among other measures, research and innovation should be encouraged to help assess AI systems and promote compliance with requirements; to disseminate the results; and to systematically train a new generation of AI ethicists. Additionally, transparency about working with an AI system is important, as well as facilitating traceability and accountability of AI systems, especially in critical contexts or situations. It also highlights the need to involve stakeholders in the complete lifecycle of AI systems. It is especially necessary to promote training and education so that the largest number of people are aware of and trained in trustworthy AI so that the development of this technology contributes to narrowing rather than deepening existing social gaps.

The AIA, a considerable step forward in responsible and people-centred AI

The European Artificial Intelligence Act (AIA)[142] undoubtedly represents a move towards responsible AI aligned with the ethical principles set out in the previous Guidelines and documents, sharing a common vision on the responsible development and deployment of artificial intelligence in the EU. Indeed, among the aims of the AIA is to promote human-centred and trustworthy AI and to ensure a high level of protection of fundamental rights. While the Guidelines establish an ethical framework based on fundamental principles, the AIA introduces specific legal obligations, especially in the assessment of social and environmental impacts in sensitive sectors.

The Act establishes a series of requirements scaled according to the risks posed by each Artificial Intelligence system to citizens' rights, banning outright, albeit with certain exceptions, those that pose an unacceptable risk (Figure 22). Systems prohibited in the European Union include, but are not limited to, those capable of transcending a person's consciousness with deliberately manipulative, deceptive or subliminal techniques to alter behaviour and cause them significant harm; those capable of causing significant harm to a particular group due to their age, disability, specific social or economic situation; systems that are designed to evaluate or classify individuals on the basis of their behaviour or personality traits; AI that performs risk assessments of individuals in order to assess or predict the risk of them committing a criminal offence, based on solely on profiling; AI designed to infer a person's emotions, except for medical or security reasons; or AI that creates or expands facial recognition databases by non-selectively scraping facial images from the internet or CCTV footage.

Human oversight is at the core of the EU AI governance system and is one of the requirements with which AI systems classified as high risk must comply (Art. 6.2), the system provider having to define appropriate human oversight measures before placing it on the market or commissioning it (Figure 23).

142 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).

FIGURE 22. SOCIAL IMPACTS OF AI: LEVELS OF RISK AND OBLIGATIONS SET BY THE AIA

EXAMPLES	RISK LEVEL	OBLIGATIONS
Subliminal techniques that transcend people's consciousness. Social classification. Predictive policing systems based on profiling only. Biometric categorisation using sensitive data (sexual orientation, religion, etc.)	UNACCEPTABLE RISK	PROHIBITED
Education, employment, critical infrastructure, health, product safety, hiring and evaluation of employees, access to essential services (credit, housing) Criminal risk assessment. Biometric systems for identification	HIGH RISK	Assessment of prior conformity. Registration in EU database. Risk management system. Automatic logging of activities. Transparency, human oversight, cybersecurity.
Chatbots, virtual assistants, imageaudio or video generators (deep-fakes.) Content recommendation. Search engines with AI-generated results.	LIMITED RISK	Transparency obligations Inform users of AI interaction
Such as spam filters, video games or creative tools. Basic word processing applications. Internal corporate analysis systems.	MINIMAL RISK	No specific obligations beyond those stipulated by the general regulations. Voluntary adoption of codes of ethics and codes of conduct

Source: Authors' own based on Artificial Intelligence Act 2024/1689.

However, some socially relevant sectors remain outside the direct scope of the AIA in terms of the obligation to assess social and environmental impacts prior to implementation. These include digital platforms and social media, for which no prior assessment of algorithmic impacts is required with regard to misinformation, social polarisation or mental health. The same is true of recommendation and advertising systems, despite their ability to influence people's financial decisions; AI models in the financial sector (with the exception of specific practices such as credit scoring) or the absence of provisions for assessing the ecological footprint of all AI applications. And to maintain Europe's competitiveness in an international context that lacks such stringent regulations as the AIA, it includes specific exemptions for AI systems used exclusively for research purposes, so that pure research projects will not be subject to the same obligations as commercial or public use systems.

1.2. ALGORITHMIC GOVERNANCE, TRANSPARENCY AND ACCOUNTABILITY

Automated decision-making (ADM) and AI are already part of the day-to-day processes substantiating important subjective rights of individuals, such as access to justice, medical treatment, social benefits or public aid, as will be seen below. For this reason, they have

FIGURE 23. SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT IN THE EUROPEAN AI ACT (AIA)

The AIA classifies AI systems according to the level of risk they pose to fundamental rights and social welfare. Apart from directly banned systems, “high-risk” systems must meet strict requirements prior to marketing or deployment, including a social and, in certain cases, environmental impact assessment.
In particular, the AIA requires:

- Ex ante assessment: Potential adverse effects on fundamental rights, including discrimination, privacy and social exclusion, should be identified.
- Environmental impact analysis: Although not a widespread requirement, there is a need to consider the ecological impact of AI use.in specific sectors such as mobility, energy or resource management,
- Human oversight and audits: Mechanisms for the control and periodic review of high-risk AI systems are established to mitigate adverse impacts.

This obligation to assess social and environmental impacts reinforces the principles of “no harm” and “responsibility” defined in the Ethics Guidelines for Trustworthy Artificial Intelligence, which stress the need to avoid harm to society and to ensure sustainable and equitable technological development.
The AIA especially regulates sectors where AI may affect fundamental rights, such as:

- Healthcare (medical diagnosis, automated treatment)
- Education (student assessment and selection systems)
- Law and order and public administration (crime prediction systems, automated decisions in public services)
- Employment and human resources (worker selection and assessment tools)
- Security and surveillance (facial recognition and anomalous behaviour detection)

an enormous potential to improve the quality and personalisation of public services, to detect social problems more accurately, to make data-driven decisions, to improve the efficiency and evaluation of public policies, to streamline procedures, and to reduce costs. However, their development may have an effect on fundamental rights such as personal data protection, privacy, security, equality and non-discrimination or access to justice, thus generating uncertainty regarding issues of responsibility. Additionally, as underlined by the European Union Agency for Fundamental Rights (FRA), other rights may also be at risk, e.g. human dignity, the right to social security and social assistance, the right to good administration (particularly relevant for the public sector) and consumer protection (particularly important for businesses) [143]. According to the FRA, depending on the context of AI usage, any other rights protected by the EU Charter of Fundamental Rights should be considered.

143 See, European Union Agency for Fundamental Rights (FRA), *Getting the Future Right: Artificial Intelligence and Fundamental Rights. Summary.* 2021.

FIGURE 24. THE IMPACT OF ALGORITHMIC OPACITY ON THE RIGHTS OF PERSONS SUBJECT TO ADMINISTRATIVE PROCEDURES

Case studies

Rotterdam-Netherlands (2017-2021). Machine learning system developed to identify potential cases of benefit fraud. The model ranked beneficiaries on a risk scale (0-1), prioritising investigations on the top 10 per cent, which could lead to cancellation of aid, reduction of aid or forced repayments. The internal audit demonstrated the use of structurally biased proxy variables such as neighbourhood of residence, mental health history and subjective assessments by social workers, leading to indirect discrimination according to the Netherlands Institute for Human Rights. Furthermore, it showed marginal accuracy, being only 50 per cent more effective than chance. Dutch courts found selection based on language skills to be discriminatory, as it disproportionately affected ethnic minorities. The lack of transparency in the scoring criteria violated principles of procedural fairness.

United Kingdom (2020). As part of the disruption to the 2019-2020 academic year during the Covid19 health crisis, thousands of British students protested against the use of a predictive algorithmic system for grades given by teachers, which had reduced their academic results following the cancellation of final exams due to national confinement. The protest movement ("Fuck the algorithm") led to the results being overturned.

BOSCO Case- Spain (2018-). The Civio Foundation demanded information on the algorithm used to approve the social voucher for electricity, given numerous rejections in cases where the requirements for the benefit had been clearly met. Access to the source code was denied by the Transparency Council (Resolution 701/2018 of 18 February 2019) and by Ruling 143/2021 of the Central Contentious-Administrative Court of 30th December. The new ruling of 30 April 2024, of the Contentious-Administrative Chamber, Section Seven, of the National High Court, in Appeal 51/2022, once again rejected access on the grounds of intellectual property and national security. In November 2024, the Supreme Court admitted Civio's cassation appeal.

VeriPol-Spain (2018-October 2024). AI tool used to detect false reports of violent robberies. It analysed the language of the complaints filed using natural language processing and machine learning techniques. Despite its effectiveness (91 per cent), it has recently been questioned for its possible biases, the low representativeness of the study sample due to its design, which did not reflect the linguistic, regional and social diversity of Spain, and did not directly processing the language of the complainants, but rather interpreting what the police had recorded.

VioGén- Spain (2007-). A risk assessment algorithm for cases of gender-based violence, which predicts the likelihood of recidivism using a hybrid model combining 37 variables (severity of violent acts, perpetrator's history, victim's vulnerability, etc.), classifying risk into five levels (from "no risk" to "extreme risk"). The adversarial audit conducted by the Eticas Foundation, in collaboration with the Ana Bella Foundation, detected failures in terms of the transparency of the algorithm, bias in the training data (it operates mainly with police data, without integrating socio-economic or contextual variables); rigidity in its application (in 95 percent of the cases the automatic score is not modified), classification errors (45 percent of the cases receive the label "no risk"), among others. Between 2003 and 2021 there were 71 femicides following previous reports with a lower risk assessment than the actual risk.

Sources: Authors' own based on Burgess, M., Schot, E. and Geiger, G. (6 March 2023). "This Algorithm Could Ruin Your Life. Wired" at: https://www.wired.com/story/welfare-algorithms-discrimination/. L. Cotino Hueso, "Caso Bosco, a la tercera tampoco va la vencida. Mal camino en el acceso los algoritmos públicos» in Diario La Ley, May 2024; https://incidentdatabase.ai/; https://eticas.ai/the-adversarial-audit-of-viogen-three-years-later/

Lack of transparency can result in systemic errors which in turn lead to unfair decisions maintained over the years, thus eroding public confidence in institutions[144]. The social impact, i.e. the consequences of errors on the population and their rights, is a key point when estimating the risk of algorithmic and automated systems, together with data quality, analysis of veracity and bias, and the technology used.

Numerous AI tools have been used in the most diverse economic and social areas even before the AIA was approved, and their requirements will entail a major effort of adaptation at a time when there is growing concern about the criteria governing automated decisions on the basic rights and obligations of citizens. It is especially important that the actions of public administrations set a benchmark in this area. According to a recent report[145], 68 percent of automated decisions in Spanish public services lacked external supervision in 2024, while the opacity of certain algorithms used in highly sensitive areas has been called into question, both in access to certain public aid and benefits and from the point of view of guaranteeing fundamental rights, in line with what has also happened in other neighbouring countries.

Within this context, algorithmic transparency becomes important, the principle according to which the factors involved in decisions made by algorithms should be visible, knowable, auditable, and explainable to the people who use, regulate, and are affected by the systems that employ these algorithms. In Spain, the Charter of Digital Rights (2021), although lacking regulatory value, already contemplated specific provisions in relation to AI (Chapter XXV), such as the right to algorithmic non-discrimination, trustworthiness, the right to supervision and challenge of automated or algorithmic decisions, or the right to information on the use of chatbots and to human assistance at the request of the person concerned (Figure 25).

In terms of regulatory development, although the first advances were made in the field of tax legislation, the first concrete positive regulation of AI came about through Comprehensive Act 15/2022 of 12th July, on equal treatment and non-discrimination. In line with European guidelines, Act 15/2022 establishes that public administrations that use algorithms for decision-making are required to promote the implementation of mechanisms to ensure that such algorithms take into account criteria of minimisation of bias, transparency and accountability, whenever technically feasible (Article 23). To this end, these mechanisms will include their design and training data, and address their potential discriminatory impact, by conducting impact assessments to identify potential discriminatory bias, which should be addressed, inter alia, through algorithmic transparency.

144 Calabuig, J. M., Cotino, L., Ferrer, A. and Sánchez E. A, *Guía práctica ¿Cómo abrir los algoritmos públicos? Recomendaciones para la implantación de registros de algoritmos públicos*, Cotino Hueso, Lorenzo (coord), Universitat Politècnica de València- Universitat de València, Version 1.0 June 2024.

145 IA Ciudadana, *Cómo lograr una transparencia real con los registros de algoritmos. Avances y políticas para diseñar, implementar y evaluar registros algorítmicos*, March 2025.

FIGURE 25. CHARTER OF DIGITAL RIGHTS (2021): RIGHTS AS REGARDS ARTIFICIAL INTELLIGENCE

1. In the development and life cycle of AI systems: a) The right to algorithmic non-discrimination shall be guaranteed, regardless of the origin, cause or nature of the bias, with regard to decisions and processes based on algorithms. b) Transparency, auditability, explainability and traceability shall be ensured. c) Accessibility, usability and reliability shall be guaranteed.

2. Persons have the right not to be subject to a decision based solely on automated decision-making processes, including those that use AI procedures, produce legal effects, or significantly affect them in a similar manner, except in the cases provided for by law. In such cases, the following rights are recognized: a) The right to request human supervision and intervention; b) The right to challenge automated or algorithmic decisions.

3. Persons shall be informed of the use of AI systems that communicate with human beings using natural language in all its forms. In all cases, assistance from a human being at the request of the interested party shall be guaranteed.

4. The use of AI systems aimed at psychologically manipulating or disturbing persons, in any aspect affecting fundamental rights, is prohibited.

The Spanish AI Strategy adopts this approach, dedicating Axis 3 to fostering a transparent, responsible and humanistic AI. In this area, the Spanish Agency for the Supervision of Artificial Intelligence (AESIA) will play an important role as it is tasked with ensuring that safe, responsible and ethical Artificial Intelligence systems are deployed in Spain. AESIA has been tasked with conducting an urgent, in-depth and comprehensive discussion in order to set clear boundaries and transparent co-governance that can guide society in the use and enjoyment of this technology. The goal is to reach consensus on the limits of algorithmic decision-making, while taking into account the specific realities of each production and social sector, via a careful and contextualised approach so that the frameworks for action favour innovation while also respecting rights. Within this context, the future creation of the Observatory on the Social Impacts of AI should contribute to the knowledge and improved governance of the Spanish AI strategy from the perspective of its contribution to the well-being, quality of life and equality of all people. Because of its commitment to these objectives and its close contact with social reality, it is necessary to include the participation of social partners into the Observatory's dynamics, in order to make its actions more effective.

Algorithm registers in public authorities, as yet isolated cases

One of the main instruments for ensuring transparent AI and automated decision-making is the creation of algorithm registers, which would inform citizens of the systems being used, their purposes, and their potential impacts, thereby fostering trust and facilitating the oversight and auditing of these systems[146].

Public administrations should be a benchmark for algorithmic transparency. However, despite the various provisions, there is as yet neither a national register[147] nor a standardised protocol for the creation of algorithm registers and their development presents a fragmented panorama, with unequal progress between administrations, although there are already certain pioneering experiences at the level of the autonomous community[148]. Thus, although not fully developed, the Regional Government of Valencia[149] has established by law the creation of the first public register of algorithms in Spain, which will gather and share information on the algorithms used by this Administration, in order to foster transparency and ensure fairer and more equitable decisions. The Catalan Public Administration has published its first guide for the preparation of detailed technical data sheets on the algorithms (training data, biases detected, review protocols, etc.) with a view to the preparation of registers of these algorithms. Likewise, Galicia, Asturias, Extremadura or recently the Basque Country are exploring how to implement algorithmic transparency, although not necessarily through the creation of registers.

Responsibility and accountability, an area in need of development

Finally, clear regulation of responsibility and accountability in case of automated decision-making is necessary to ensure the right of citizens to appeal automated decisions that adversely affect them and to be awarded compensation in case of damages.

The objective system of pecuniary liability is applicable in the case of public administrations, regardless of whether the action is attributable to a natural person employed by a public administration or to an algorithm or other automated decision-making tool. However, some ongoing cases point to the complexity of such processes[150]. It is especially difficult to attribute responsibility in AI systems and robots designed to learn from experience, given the unpredictability of some of the learning that can take place,

146 Cotino Hueso, L. “Qué concreta transparencia e información de algoritmos e inteligencia artificial es la debida”, Revista Española de la Transparencia, Núm. 16 (Semester 1. January - June 2023).

147 Although the Draft Bill for the proper use of Artificial Intelligence introduces transparency requirements in the case of high-risk systems, as provided for in the European Regulation.

148 IA Ciudadana, *Cómo lograr una transparencia real con los registros de algoritmos. Avances y políticas para diseñar, implementar y evaluar registros algorítmicos*, March 2025.

149 Act 1/2022, of 13 April, on Transparency and Good Governance of the Valencian Community.

150 Thus, in the so-called “BOSCO case”, the Civio Foundation’s request for access to the source code has been denied on three occasions. In contrast, the source code of Radar COVID, the application created to track and report COVID-19 positive contacts, was released by the government for transparency and for community collaboration in order to improve the app.

especially in the absence of adequate human supervision. In the field of Private Law, litigation arising from the advent of robotics and Artificial Intelligence is a growing reality that raises numerous challenges around issues such as the general legal status of robots and the recognition of a possible robotic person, the challenges of human-robot interaction, or civil liability issues. The impact of the possible generalised implementation of self-driving cars and the adaptation of the current liability regime for traffic accidents to this new paradigm, or the challenges of the eventual replacement of workers by AI tools are some of the cases most analysed by the doctrine.[151]

An opportunity for progress in this area may be in the form of the Draft Bill for the proper use of Artificial Intelligence (AI), whose public hearing phase was completed on 26 March 2025. Among its major stated objectives is to ensure the ethical, inclusive and beneficial use of this technology by bringing national legislation in line with the European AI Act. It includes new features such as the launch of a *sandbox* or regulatory testing ground, as well as incorporating a regime of infringements and penalties for failure to comply with the AIA.

1.3. TOWARDS NON-DISCRIMINATORY AI: A SPECIFIC LOOK AT GENDER BIASES

The prevention and fight against different forms of discrimination is a constitutional mandate in Spain, developed through a comprehensive regulatory framework whose compliance plays a fundamental role in ensuring the protection of rights within the context of AI usage. It must be developed and implemented in accordance with ethical and legal principles that safeguard individual rights and freedoms, ensuring that the systems and algorithms used "internalise" compliance with the principles of non-discrimination and do not simply replicate and magnify existing biases in society, anticipating potential risks and ethical challenges beyond regulatory compliance. This requires the adoption of preventive, proactive and ethical approaches to their development and application, establishing supervision and control mechanisms that guarantee rights and freedoms in their use.

One of the most obvious examples of the risk of discriminatory bias concerns the treatment of women in the AI environment. While Artificial Intelligence offers enormous potential for societal advancement and economic dynamism, its advances are also accompanied by numerous challenges, especially in terms of preventing and eradicating gender inequalities and discrimination, especially as women are under-represented in the field of technology.

Imbalances in the representation of women in AI or the assumption of stereotypes present in society in training data may increase or generate discrimination and prejudice, thus hindering its potential to offer solutions to important social problems that especially affect women, both today and in the future. This problem, already highlight-

151 See, Barrio Andrés, M., "Cuestiones actuales del Derecho de los robots" as well as Barrio Andrés, M. (dir.) (2018): *Derecho de los robots.* Madrid: Wolters and Kluwers.

ed by the Economic and Social Council (ESC) in its Report 1/2022, *Women, work and care*, arises from the moment of creation of datasets, their compilation and use, to the development of AI solutions (Figure 26).

Given that women are underrepresented at all stages of the process of data collection, design, development and implementation of AI tools, it may be argued that the solutions do not meet the needs of half of the world's population. Hence the importance of initiatives aimed at redressing gender inequalities by driving advances in non-discriminatory algorithms and data sources, and encouraging girls, women and under-represented groups to participate in AI[152].

FIGURE 26. ARTIFICIAL INTELLIGENCE AND RISK OF GENDER BIAS

1. Mechanisms of bias perpetuation

- Unbalanced data: Information-trained models where roles such as "nurse" are mostly associated with women and "scientist" with men, perpetuating occupational segregation.
- Lack of diversity in development teams, given the under-representation of women in professional AI teams.
- Opaque algorithms that internalise discrimination by prioritising male CVs based on historical patterns in automated recruitment systems.

2. Examples of concrete cases

Medical diagnoses: AI models trained with clinical data focusing on male symptoms have underdiagnosed conditions such as heart disease in women, affecting their access to treatment.

Social interaction: Default female voices in virtual assistants reinforce submissive stereotypes, while other systems use male voices in authoritative contexts, such as medical diagnoses.

Law and order: Algorithmic opacity can make it difficult to prove bias in judicial processes, weakening the application of effective gender equality regulations.

Intersectional bias: A study by the MIT Media Lab (2018) demonstrated that come facial recognition systems of tech companies have higher error rates for women, especially racialised women, with error rates up to 34% higher compared to white men.

Source: Authors' own based on data from Instituto de las Mujeres, Author: Lorena Jaume-Palasí, Preliminary report with an intersectional perspective on gender bias in artificial intelligence, Ministry of Equality, 2023. UN Women, How AI reinforces gender bias—and what we can do about it, 02/2025 Authors' own based on IPI, Ardra Manasi, Subadra Panchanadeswaran and Emily Sours, Global Observatory, "Addressing Gender Bias for Ethical AI", on 17 March 2023; MIT Media Lab, Joy Buolamwini (coord.) "Gender Shades" (2018).

152 Among others, UNESCO's "Women4Ethical AI" platform is aimed at supporting the efforts of governments and companies to ensure that women are fairly represented in both AI design and implementation. Members of the platform will also contribute to the advancement of all ethical provisions of the UNESCO Recommendation.

Recent studies published in Spain delve deeper into the problem of gender bias, pointing to different solutions in the same direction indicated by international organisations[153]. It therefore points to the need to reduce gender bias in the design, development and implementation of AI through a comprehensive approach that combines enforcement, independent audits, encouraging greater participation of women, and the inclusion of a gender perspective in all phases of data engineering, with the goal of redefining AI as a tool for equality.

Other risks of bias and stereotypes, such as ageism, also require assessment and prevention

Similar precautions apply to other biases present in society, such as stereotypes regarding age (ageism), illness or disability, gender identity or sexual orientation, origin and, in general, all circumstances protected by equal treatment and non-discrimination regulations. Within the international context, the Canadian experience in implementing a protocol called the Algorithmic Impact Assessment (AIA[154]) tool, which helps to assess and mitigate the impacts associated with the implementation of automated decision-making systems, is often cited as an example.

A particularly sensitive issue is the risk of AI facilitating, replicating or amplifying situations of gender-based violence, harassment, misinformation and hate crimes that are rampant in society. It is important, therefore, to look more closely to the advances that are being made, in terms of their use to tackle precisely this type of violence, with special attention to the development of algorithms for detecting violent content, hate speech and counter-narrative tools[155].

2. Impact of AI on welfare and social protection policies

Despite the lack of visibility of AI applications currently used to manage the major dimensions of social protection and welfare policies, the following are some of its impacts generated in important areas such as education, social security and social services, and healthcare[156].

2.1. CHALLENGES AND OPPORTUNITIES FOR EDUCATION

By means of technologies such as generative AI (GenAI), Artificial Intelligence is able to replicate human capabilities to generate content of all kinds, such as written texts, images, videos, music, etc.[157] Although its use is fairly recent, it has become extremely popular

153 Instituto de las Mujeres, Author: Lorena Jaume-Palasí, *Informe preliminar con perspectiva interseccional sobre sesgos de género en la inteligencia artificial*, Spanish Ministry of Equality, 2023.

154 https://code.iadb.org/es/herramientas/algorithmic-impact-assessment

155 These are tools that are beginning to be used by institutions and agencies such as CEPOL, the European Commission, the European Union Agency for Fundamental Rights, EUROPOL, the Public Prosecutor's Office and different ministries and digital platforms.

156 On the impact of AI on health and the public healthcare system, see Chapter V, section 2 on the opportunities and challenges of health digitalisation in Report 1/2024, *Healthcare system: current situation and perspectives for the future,* of the Economic and Social Council (ESC).

157 GenAI is an AI technology that generates content automatically in response to instructions (*prompts*).

among Spanish pupils (over 80 per cent of 14-17 year-old students admit to having used AI, and 40 per cent say they use ChatGPT frequently). A large percentage of teachers (73 per cent) and families (69 per cent) also claim to have used AI[158]. Moreover, their use is expected to increase exponentially as these tools, which are in full expansion, become more powerful.

However, due to the relatively recent emergence of GenAI, its implementation in education is still limited, which has raised numerous questions regarding its impact on knowledge creation and transfer, teaching and learning, and curriculum design and evaluation. The possibility of delegating to machines what has been the exclusive domain of human intelligence has been a major paradigm shift, giving rise to conflicting views on its benefits and risks for education (Figure 27).

On one hand, although its real impact on education is currently unknown, it is considered to have significant potential in the field of education and learning. The possibility of automating basic levels of knowledge creation enables learning and teaching processes to be freed from lower-order tasks, allowing them to focus on more complex tasks that belong to the realm of higher-order thinking. It also facilitates the presentation and visualisation of results, which has important advantages in terms of teaching and learning.

Another consideration is that GenAI may help to adapt education to the needs of students, which is of especial interest for those with special needs (dyslexia, visual or hearing difficulties, or with socio-emotional or learning problems). It also reduces the amount of teaching time spent on more routine and management-related tasks in order to focus more on developing content and teaching methods, and to provide greater personalised attention to students.

These improvements, however, are accompanied by significant learning challenges. Since GenAI is trained on the information it obtains from the internet, it can generate erroneous or biased content, as well as offensive, discriminatory or unethical content, as mentioned above. Moreover, although it is capable of reproducing results, it does not always provide correct answers to many real-world problems. Within educational contexts that influence the development of the individual from childhood onwards, it is even more important to implement AI according to ethical guidelines that include the human rights and social values that underpin societies. Likewise, there is a need to ensure that using these tools does not amplify problems of digital inequality or poverty, or the risk that students or schools with limited digital capabilities are excluded, as well as ensuring the inclusion of content related to local issues or minority populations or languages. Furthermore, it poses not a few challenges in relation to the security and reliability of results, data privacy, and copyright, among others[159].

158 Oficina de Ciencia y Tecnología del Congreso de los Diputados, *Inteligencia artificial y educación*, 2024.

159 For more detail on the benefits and risks of AI in education, see: Oficina de Ciencia y Tecnología del Congreso de los Diputados, 2024, op. cit.; Council of Europe, *AI and education. 2nd working conference*, October 2024; OECD, *The potential impact of AI on equity and inclusion in education*, 2024; UNESCO, *Guidance for Generative AI in Education and Research*, 2024.

FIGURE 27. BENEFITS AND RISKS OF AI IN EDUCATION

BENEFITS OF GENERATIVE AI IN EDUCATION	
Process automation Automates information processing, allowing students and teachers to focus on more complex tasks.	***Cognitive freedom*** Frees human beings from lower-order thinking tasks, allowing them to focus on higher-order thinking skills.
Presentation of results Facilitates the visualisation and presentation of results in various key symbolic representations of human thought.	***New ways of learning*** Transforms the understanding of human intelligence and learning, opening up new pedagogical possibilities.
Knowledge products Offers semi-finished knowledge products that may be refined and tailored to specific needs.	***Adaptive learning*** Enables the adaptation of content and teaching methods to the individual needs of the students.

RISKS OF GENERATIVE AI IN EDUCATION	
Digital Poverty: Problems of exclusion (students/schools) Concentration of resources in large technology companies Lack of local relevance	***Content Usage:*** Lack of consent of owners Copyright infringement Non-compliance with data protection regulations Inability to delete data after training the model
Regulatory Issues: Lack of independent academic review Excessive intellectual property protection Legislation lagging behind technological development	***Black Boxes:*** Opaque internal functioning Inexplicable results Perpetuation of existing biases Trust issues

Source: Authors' own based on specialised literature.

Although the real impacts of the current versions of GenAI on education have yet to be tested, it is undoubtedly a tool that is leading to a rethinking of educational policies, both in the processes of human knowledge and learning, as well as in the regulations to guarantee users' rights.

Measures and actions aimed at implementing AI in the educational sphere

The policy challenge posed by these new AI technologies is to ensure that they are useful and beneficial tools for the educational community and for the population at large, and that they do not jeopardise students' rights, learning and quality of teaching.

It is for this reason that many initiatives have been launched within a short period of time which propose regulatory measures or actions aimed at limiting the adverse effects of AI, although much remains to be done, especially in the field of education. Not surprisingly, according to a survey of EU Member States conducted by the European

FIGURE 28. INITIATIVES ADOPTED WITH REGARD TO AI IN EDUCATION

UNESCO
- *AI and education: guidance for policy makers*
- *Guidance for generative AI in education and research.*
- *ChatGPT and artificial intelligence in higher education.*
- *The potential impact of AI on equity and inclusion in education.*
- *AI competency framework for teachers.*
- *AI competency framework for students.*

Council of Europe
- Artificial intelligence and education: a critical view through the lens of human rights, democracy and the rule of law.
- Regulating the use of AI systems in education (1º and 2º working conferences).

European Commission
- Digital Education Action Plan 2021-2027.
- *Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators.*

Source: Authors' own.

Council, while most of them have implemented or are in the process of approving AI policies or strategies, hardly any specific initiatives have been developed in the field of education, Spain being one of the few countries that have done so[160].

This is why various organisations, such as UNESCO, the European Commission and the Council of Europe, have developed guidelines and recommendations to help states obtain the greatest benefit from AI technologies in education, as well as to address the risks and challenges they pose (Figure 29).

The new European Artificial Intelligence Act considers specific provisions related to education and training, including AI systems aimed at determining admission processes, assessment of learning and education, as well as for monitoring or detecting prohibited behaviours for students, among those systems deemed high-risk[161] (Figure 29). This specific regulation on high-risk AI entered into force on 2 February 2025, and from 2 August 2025 they may be subject to sanction.

At the national level, the Digital Spain Agenda 2026 and the National Plan for Digital Skills propose initiatives to improve the digital skills of the population, just as the National Artificial Intelligence Strategy contemplates the need to promote digital skills. It is also expected that projects dedicated to education will be included in the first call for the aforesaid AI Sandbox (controlled test environment) for high-risk systems.

160 UNESCO, *Guidance for Generative AI in Education and Research*, 2024.
161 High risk, as defined by the European Artificial Intelligence Regulation, is the level of all AI systems that significantly affect the safety, health or fundamental rights of European citizens.

FIGURE 29. HIGH-RISK AI IN EDUCATION AND VOCATIONAL TRAINING

a) AI systems intended to be used to determine **access or admission or to assign natural persons to educational and vocational training institutions** at all levels.
b) AI systems intended to be used to **evaluate learning outcomes**, including when those outcomes are used to steer the learning process of natural persons in educational and vocational training institutions at all levels;
c) AI systems intended to be used for the purpose of **assessing the appropriate level of education** that an individual will receive or will be able to access, in the context of or within educational and vocational training institutions at all levels;
d) AI systems intended to be used for **monitoring and detecting prohibited behaviour** of students during tests in the context of or within educational and vocational training institutions at all levels.

Source: Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence. Annex III.

The Plan for the Digitalisation and Digital Competences of the Education System (Plan #EdEdu) was specifically approved for the digitalisation of the education system, which seeks to improve the availability of technological resources for the education community; as well as the Spanish Plan for the Digitalisation and Digital Competences of the Education System (#CompDigEdu), which seeks the effective and efficient integration of technologies in the teaching and learning processes. It is also worth mentioning the guidelines on the use of AI in the education system launched by the National Institute of Educational Technologies and Teacher Training[162], as well as by some autonomous communities such as Catalonia and the Canary Islands[163].

The need to train teachers for the responsible and effective use of AI in education

AI, as discussed above, can have enormous benefits in education and, more specifically, for teaching processes, having a major impact on teaching activity. It is an opportunity for personalised learning, virtual tutoring, automation of administrative tasks, data analysis, and the creation of educational resources, among others. These constitute potential advantages for Spanish teachers, given that approximately half of their working day is spent on non-teaching tasks such as planning and preparing lessons, marking pupils' work, and communicating or cooperating with families or tutors, among oth-

162 INTEF, *Guide on the use of Artificial Intelligence in education*, 2024.
163 Government of Catalonia, *La intelligència artificial en l'educació*, 2024; Government of the Canary Islands, *Guía para el Uso de la Inteligencia Artificial en Educación*, 2024.

ers[164]. According to some estimates, using AI for non-teaching tasks could save Spanish teachers up to one working day per week[165].

Getting the most out of AI in education therefore requires a significant change in teaching methodologies and content, as well as more digital training for teachers, who have little training in science, technology, engineering and mathematics (STEM) subjects[166]. And, more specifically with regard to the operational and beneficial applications of AI for learning, teachers must be provided with training and skills on the basic concepts of AI (teaching about AI), on the challenges and opportunities of this type of tool for learning (teaching for AI), and they must be prepared for its application in the educational context (teaching with AI).

In Spain and within in the context of the pandemic, the *Educa en Digital* (Educate Digitally) programme was launched to improve the digital skills of teachers. The #DigEdu Plan in turn provides for the digital skills certification of teachers. The National Institute of Educational Technologies and Teacher Training (INTEF) of Spain also has a varied educational programme for teachers at national level, as do some regional administrations, as mentioned above.

However, teachers' participation in continuing occupational development, although high, is lower than the EU average (91.8 per cent compared to 94.3 per cent in the EU), which may be due to a lack of incentives as well as work-life balance[167]. To this must

FIGURE 30. BASIC DIMENSIONS OF AI IN EDUCATION

- **Teaching about AI**: technical approach aimed at understanding and applying AI in order to use it effectively (such as programming a simple AI-based solution to understand how it works)
- **Teaching for AI:**. development and acquisition of skills and competences relevant to AI challenges and opportunities (such as understanding potential biases in content, using computational thinking to solve problems, or being aware of risks related to data protection).
- **Teaching with AI**: integrating AI into the educational environment to enhance the teaching-learning process.

Source: European Commission, *Use Scenarios & Practical Examples of AI Use in Education*.

164 For further details on the teaching profession in Spain, see: European Commission, *Education and Training Monitor*, 2023.

165 National Office of Foresight and Strategy. *Hispania 2040, How artificial intelligence will improve our future*, 2024. Studies conducted in other countries estimate that around 20-40 per cent of the tasks performed by teachers could be automated with AI, which would mean a reduction to 13 hours per week. For more details, see OECD, *The potential impact of AI on equity and inclusion in education*. 2024.

166 According to the Education and Training Monitor, 2023, *op. cit*. this may be partly due to the fact that graduates in STEM fields find better working conditions in industry, with the result that these positions often have to be filled by interim teachers.

167 European Commission, *Education and Training Monitor*, 2023.

be added the data from a recent study that highlights the working conditions of teachers, which notes increased fatigue, feelings of isolation and disaffection, as well as high rates of temporary work, which can negatively impact their motivation to acquire digital skills[168]. This is more so if one takes into account the effort required of teachers to implement skills-based training since the LOMLOE was approved, as has been pointed out in the chapter on training and education.

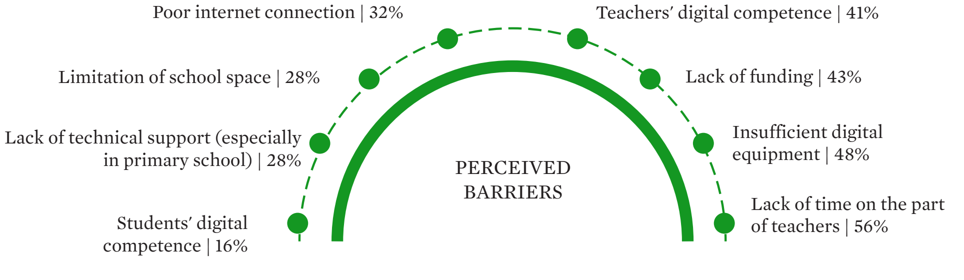
Boosting ICT equipment and funding in schools

To this must be added the difficulties faced by teachers, school administrations and students in sourcing equipment and funding for schools to meet the challenges posed by digitalisation in general, and teaching about AI in particular (Graph 19)[169]. In this regard, according to OECD data, a significant number of school principals in Spain consider that their schools lack digital resources or that these are insufficient or of poor quality, affecting around one in four students in Spain, above the European average. In contrast, the percentage of teachers who consider that they require training in digital skills for teaching is among the lowest in the EU (Graph 20). However, it is likely that this positive performance has more to do with a lack of resources and less use of digital tools for teaching in Spain, which means that teachers do not perceiving digital skills training as a requirement.

Developing AI skills for students and the lifelong learning of the population

Additionally, people must be equipped with digital skills, as these are the basic tools for learning how to use and manage AI. In this regard, and as a complement to the initiatives adopted by the European Commission in this area, it is worth highlighting the recent launch of the *Union of Skills* package, which proposes actions aimed at promoting basic and advanced digital skills in European education systems and in lifelong learning programmes[170].

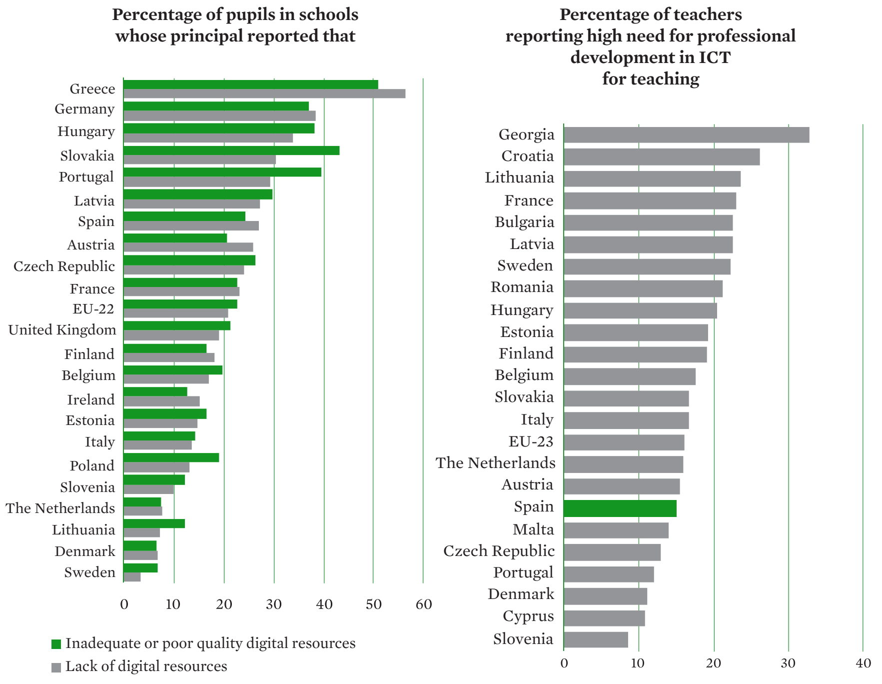
GRAPH 19. PERCEIVED BARRIERS TO TEACHING WITH DIGITAL TECHNOLOGIES



Source: Ministry of Education and Vocational Training, *The digital capacity of primary and secondary schools in Spain*, 2021.

168 EsadePol, *The state of the teaching profession in Spain*, 2025.
169 The study is based on a survey of a sample of 1,721 members of school administration teams, 7,934 teachers and 16,648 students, who assessed the situation in 492 primary, secondary and baccalaureate schools throughout Spain.
170 European Commission, *Union of Skills*, COM (2025) 90 final.

GRAPH 20. COMPARATIVE STATUS OF DIGITAL RESOURCES AND THE NEED FOR TEACHER TRAINING IN ICT SKILLS



Source: Left-hand panel: OECD (2023), PISA 2022 Results (Volume II). Right-hand panel: OECD (2018[129]), TALIS 2018 Database.

Although Spain starts from a relatively advantageous position in the Digital Economy and Society Index (11th place overall[171]), it displays significant weaknesses in this field. Thus, 43 per cent of the Spanish population lacks basic digital skills and 8 per cent have never used the internet. Moreover, only 4% of the graduate population has graduated in an ICT-related degree, which moreover has a significant gender gap[172].

The Digital Spain 2025 Agenda lists among its 10 priority points, strengthening the digital training of all citizens, as well as ensuring adequate digital connectivity for the entire population and thereby encouraging the disappearance of the digital divide between rural and urban areas. In order to make progress towards these objectives, the National Plan for Digital Skills has established lines of action aimed at improving the digital skills of the people[173].

171 The Digital Economy and Society Index (DESI) compares the digital performance of the member states of the European Union on a yearly basis.
172 As detailed in the National Plan for Digital Skills.
173 The Plan focuses on seven different areas: 1) ensuring digital inclusion for all people; 2) reducing the gender-based digital divide; 3) promoting the acquisition of digital skills for education by teachers and students at all levels of the education system; 4) advanced digital skills for workers; 5) digital skills for

Leaving no one behind: bridging the digital divide in the face of AI

Within the field of education, the Education Act (LOMLOE) guarantees the full integration of students into the digital society through a critical and safe use of digital media that respects human dignity, social justice and environmental sustainability, constitutional values, fundamental rights and, in particular, respect for and guaranteeing personal and family privacy and personal data protection. Based on these core objectives, this regulation has included digital skills in curricular design at different educational stages[174]. Likewise, specific university and vocational training courses on AI have been approved, which are of great importance for ensure the availability of professionals in this field demanded by the labour market, as seen in Chapter II of the ESC Report 2024[175].

However, as digital skills are a basic requirement for the appropriate use of AI, the education system and lifelong learning programmes must provide training specifically geared towards the use of AI-based tools. In other words, people must be equipped with skills that enable them to take advantage of these tools, as well as to manage the risks they entail in terms of content, interpretation of results, privacy and security, among others, based on ethical, humanistic and critical thinking values.

Equal access to GenAI systems must be also guaranteed in order to prevent them from reproducing, and even deepening, existing gaps in access to technology and educational resources, which are especially noticeable in schools with the most economically vulnerable pupils[176]. In this sense, the #DigEdu Plan, with an investment of 1.4 billion euros per year, aims to reduce the digital divide through the distribution of digital devices and the improvement of digital equipment available in classrooms. Alongside such measures, quality tools should also be developed that are freely accessible to the public at large.

The horizon: making further progress in harnessing the benefits of AI in education and training

AI is advancing by leaps and bounds, as is its use among the population, and although Spain is one of the few countries where specific initiatives have been adopted for education, there is no doubt that there is still a long way to go.

AI represents a paradigm shift that must be harnessed to exploit its enormous potential in the field of education and training. Moreover, given that AI progress is unstop-

civil servants and employees of public administrations; 6) digital skills for Spanish companies in general and especially SMEs; and 7) the development of ICT specialists.

174 For more details, see: https://intef.es/competencia-digital-educativa/competencia-digital-del-alumnado/

175 As stated in the AI Strategy, around fifteen public universities were offering undergraduate degrees in AI and Data Science and Engineering in the 2022-2023 academic year, and more than twenty master's degrees in general AI or specialising in Business Intelligence, Visualisation, or Computational Intelligence. During the same academic year, private universities offered five Bachelor's and five Master's degrees in these subjects.

176 For more detail, see OECD, *The potential impact of AI on equity and inclusion in education*. 2024.

pable, it is important that measures continue to be taken in parallel with its growth and the improvement of tools associated with this technology in order to avoid its associated risks.

Ongoing evaluations of the impacts of AI in education is required in order to understand the real benefits and problems it generates in the field of teaching and learning.

On the other hand, to achieve a balanced development between technological advances in AI and the training and educational needs of citizens according to the principles of equality, quality and inclusion that govern educational policies, mechanisms for collaboration and governance must be established between the different areas involved in the field of education.

2.2. THE USE OF AI AND BIG DATA IN SOCIAL SECURITY MANAGEMENT

Artificial Intelligence and Big Data are playing an increasingly relevant role in public administration and especially in Social Security. One example of this was Spanish Social Security's rapid response during the COVID-19 health crisis, thanks to these technologies, by the promotion of digital public services.

The huge volume of data and administrative processes generated by the Social Security Administration and the fact that it is one of the administrations closest to citizens, given its functions in both the field of social welfare –through benefits– and in labour matters –through Social Security affiliation and the collection of social contributions–, makes it a particularly favourable environment for the adoption of AI and Big Data technologies[177].

By means of these technologies, different tools have been incorporated into the management of the Social Security system, aimed broadly at automating processes, optimising resources, and providing services. The goal should be, on one hand, to improve the efficiency of the system, reducing costs and administrative burdens, streamlining benefits management, reducing waiting times and optimising planning, and allocating resources according to the real needs of the population and future trends[178]. And, on the other hand, to guarantee quality services that meet the needs of the population, ensuring social justice and the protection of the most vulnerable groups[179].

The implementation of AI and Big Data in Social Security management

One of the most significant advances has to do with the automation of administrative procedures and procedures in areas such as the granting of benefits, the verification of requirements or the processing of files. Automated processing has made it possible to digitalise many administra-

177 Villar Cañada, I. "La digitalización y los sistemas de protección social: oportunidades y desafíos". Centre for Financial Studies. *Revista de Trabajo y Seguridad Social* Nº. 459, 2021.

178 Romero Coronado, J. "Impacto del Big Data y la Inteligencia Artificial en la gestión de la Seguridad Social". *Revista de Derecho de la Seguridad Social. Laborum*. Extraordinary Issue N.º. 6 (2024).

179 Villar Cañada, I., *op. cit*.

tive procedures, reducing processing times and thus the workload of public employees, speeding up procedures for citizens, increasing the efficiency of the system and reducing errors[180].

One example is the RED System, a service offered by the General Treasury of the Social Security (TGSS) since 1995 to companies, groups of companies and professionals, which has been modernised over the years with the use of *Big Data*, and allows for electronic procedures in the areas of affiliation management, contributions and collection from companies and self-employed workers.

Another example is the Alfa PREMIUM initiative, launched at the end of 2020 by the National Social Security Institute (INSS), for the processing of retirement and widowhood benefits. The process consists of entering the data provided by citizens in their application into the application, after which the file enters the Alfa application's calculation engine, where one of three things may happen: it is classified as 'Premium' and resolved without the intervention of a processor; it is classified as 'Semi-Premium' if a certain action cannot be automated and requires the intervention of the processor; or it is classified as 'Non-Premium' and the traditional procedure continues with user intervention in all phases of the process.

FIE (launched by the INSS at the end of 2019) and FIER (available from September 2021 for companies with fewer than 25 workers) are communication channels that allow companies to receive information on their workers' benefits through automated processes, to facilitate HR actions. To this end, a file is compiled daily with information on benefits that affect employment contracts or employer obligations with Social Security, such as temporary disability, permanent disability, retirement, birth and care of a child, risk during breastfeeding, risk during pregnancy or care of children with cancer or other serious illnesses.

Likewise, in April 2021 the General Treasury of the Social Security (TGSS) launched the Import@ss portal, a digital space offering information and processing services to citizens, with the inclusion of a personal area, where they can consult personal data, obtain employment history reports, manage registrations and cancellations, and make queries regarding payments and dues.

On the other hand, in the field of automated administrative action, Royal Decree-Act 2/2021, of 26th January, on the reinforcement and consolidation of social measures in defence of employment, introduced into Social Security the initiation of administrative procedures by means of automated infringement reports, where there is no direct intervention by an official acting in their issuance. In this way, the administrative sanctioning procedure in the social order is adapted to the possibilities provided by the new

180 Fernández Ramírez, M. "Inteligencia Artificial, Algoritmos Predictivos y Gestión Tecnológica de la Seguridad Social". Las transformaciones de la Seguridad Social ante los retos de la era digital: VII Congreso Internacional y XX Congreso Nacional de la Asociación Española de Salud y Seguridad Social. Asociación Española de Salud y Seguridad Social, Vol. 1, 2023.

technologies, through a special procedure initiated by issuing automated infringement reports, with the legal guarantees of those administered. This procedure reduces response times to requests submitted by citizens, mitigates administrative workloads and makes services available at any time.

Another important use of AI in the field of social security is data analysis and fraud detection. The use of machine learning algorithms in combination with Big Data, makes it possible to analyse large volumes of data in real time, with the aim of identifying unusual patterns and anomalies that could indicate problems or situations requiring immediate attention[181]. These technologies are being used mainly for the development of advanced systems for detecting fraud in the quotation or claiming of benefits. Since 2015, the Directorate General of the Labour and Social Security Inspectorate has been using a software based on Artificial Intelligence (data analysis), called the Anti-Fraud Tool.

Additionally, since 2018, the National Social Security Institute (INSS) has been using an Artificial Intelligence algorithm to monitor employees on sick leave and detect possible fraud as part of the LINCE project (predictive models based on AI and machine learning). The system, known as the Appointment Prioritisation Model, assesses people's health status and predicts the likelihood of their fitness to return to work. Thus, based on the predictions of the algorithms, the system determines which files the INSS medical inspectors should review first and which ones they will leave for last. If the algorithm detects that someone should have been reinstated but has not, the system flags the file as a possible fraud case for further review.

Furthermore, by analysing data with Artificial Intelligence, it is possible to identify suspicious behaviour, such as the submission of multiple benefit claims from the same IP address or patterns of claims that do not match the claimant's work history.

In the field of customer service, the implementation of virtual assistants and chatbots has improved interactions between citizens and the Social Security, reducing waiting times and helping to reduce the workload of public employees. These are tools that simulate human behaviour and allow user queries to be answered autonomously, offering personalised attention 24 hours a day. In addition to answering queries, they can also be able to redirect citizens to the relevant department or schedule appointments.

At the end of 2020, within the context of the pandemic, the Social Security launched a virtual assistant called ISSA (Artificial Intelligence+Social Security), which provides information and guidance to citizens on the most popular Social Security services such as administrative procedures, benefit applications and other issues related to the Management Bodies of Social Security and Common Services. The platform incorporates AI and machine learning techniques that continuously enhance the assistant so it may adapt to citizens' requirements.

181 Romero Coronado, J., *op. cit*.

AI can also contribute to better planning and resource allocation in social security through predictive models that analyse trends in the labour market, demographic changes and economic behaviour. This information allows authorities to anticipate future needs by analysing trends and historical data, making it possible to anticipate future challenges and design more effective response strategies. This predictive capability is especially relevant in the management of pensions, unemployment benefits and subsidies.

Finally, the digitisation of files and the interoperability of systems between administrations through AI contributes to improving inter-institutional coordination, facilitating and improving data integration and efficiency in the management of services, and thus providing a faster response to citizens' needs.

Challenges and risks of AI in Social Security

However, despite the multiple benefits of all these tools, their implementation also poses significant challenges. One of the main issues is data protection and the privacy of citizens' information[182]. Given that Social Security handles a large amount of highly sensitive data on citizens, such as medical records, employment information or income and benefits received, ensuring the security of this information is of critical importance for the protection of people's rights and to prevent the misuse of this data.

Another challenge has to do with fairness in automated decision-making. Algorithms may have biases that negatively affect certain population groups and companies and may lead to discrimination in the granting of benefits or in the assessment of cases[183]. To mitigate this risk, it is essential to ensure transparency in AI models and to establish mechanisms for human oversight and algorithm audits to assess the performance of AI systems and correct possible biases or errors, in order to ensure fair and non-discriminatory decisions. In this regard, a balance must be struck between automation and human control, clearly defining which decisions should remain under human supervision.

Another important challenge is the adaptation of public employees to the use of these technologies, for which it is necessary to invest in their education and training in AI and data management systems, as well as fostering multidisciplinary teams in public administrations which combine technical knowledge with experience in administrative management.

Finally, the decrease in personal attention in Social Security centres, both due to a lack of staff and the commitment to digitalisation, is leading to the exclusion of a significant part of the population, especially the elderly, people with disabilities, or people with low resources, who lack the knowledge and/or resources to access and use the

182 Villar Cañada, I., *op. cit.*.
183 Fernández Ramírez, M., *op. cit.*

necessary technologies. In this regard, it is necessary to reduce the digital divide and ensure accessibility for all citizens, by maintaining face-to-face options.

Ultimately, the implementation of AI in Social Security must be backed by a solid regulatory framework and effective human oversight to ensure its ethical, transparent and equitable use, avoiding biases and risks and guaranteeing citizens' rights.

2.3. AI AS A BRIDGE TO MORE INCLUSIVE SOCIAL SERVICES AND BENEFITS

In recent decades, the progressive incorporation of technological tools in the provision of social services of all kinds has contributed to transforming how citizens relate to the administration. Thus, the extension of service catalogues under a "digital self-management" principle (self-service solutions) streamlines administrative processes and saves time for its users. However, e-government can also create barriers for certain digitally excluded groups. Those who generally have the greatest difficulties in accessing digital media are those in the most vulnerable, precarious or marginalised situations: the homeless, the unemployed, those with drug addiction problems, or people with some kind of disability, among others[184]. These groups face additional barriers in accessing social services and benefits, which not only poses a problem for the effectiveness and efficiency of the policy portfolio, but can exacerbate the situation of vulnerability and economic exclusion of these groups.

Within this context, social services and the management of benefits have been especially sensitive to the implementation of Artificial Intelligence and Big Data tools in order to provide a better and faster response to users. Given the magnitude of benefits managed annually by various administrations, and the importance of guaranteeing access to those who need them, the massive use of data, their interconnectedness, and the automation of concession processes, allows administrations to significantly streamline their management, reducing waiting times, user uncertainty and gaps in coverage (Figure 31).

Moreover, beyond the optimisation of benefit processing, Artificial Intelligence technologies, Big Data or deep learning, can provide governments with extended and precious knowledge of social needs, which in turn can serve as a basis for improving the effectiveness of public policies in general and social policy in particular.

Technological innovation in the field of social services

One area where process automation and improved knowledge of social requirements can make a significant difference is in social services. This is a context in which professionals may be overburdened at both professional and structural levels due to a high level of procedural bureaucratisation, high volume and complexity of cases to be managed, as well as insuf-

184 Schou, J., & Pors, A. S. (2019). Digital by default? A qualitative study of exclusion in digitised welfare. *Social Policy & Administration*, 53(3), 464-477. https://doi.org/10.1111/spol.12470

FIGURE 31. POTENTIAL OF ARTIFICIAL INTELLIGENCE IN SOCIAL SERVICES AND BENEFITS MANAGEMENT

Public administrations	Social services and social workers	Citizens
Automation of eligibility assessments and investigative processes Predictive analytics for social risk assessments Real-time data-driven resource allocation Evaluating the impact of social programmes and identifying areas for improvement Increased policy efficiency and effectiveness (reduce coverage gaps-NTU) Fraud detection and prevention	Case prioritisation according to urgency, risk and need Predictive analytics for better case management Streamlining admissions and assessment of beneficiaries Integrated systems for a comprehensive view of beneficiaries Quality Assurance assistant: assessment and support in decision-making by providing evidence-based case information Real-time monitoring of progress and feedback from the beneficiary Intelligent documentation assistant: document automation and summaries Administrative assistance: automation of routine administrative tasks	Faster access to the service/benefits portfolio Chatbots or virtual assistants for access to information and services(easy reading and instant translation into different languages). Automatic reminders for appointments, document submission and renewals Assistance in the application and completion of application forms for different benefits/benefits and services. Providing a holistic view of a citizen's eligibility and access to services Customisation of various human services care plans

Source: adapted from EY (2024), *IA for social protection.. Understanding the potential of AI in human services,* European Social Services Conference, Belgium.

ficient technical and technological support resources[185]. Within this context, AI and Big Data appear as solutions that contribute to reducing the bureaucratic load of social workers, as well as providing a better understanding of the heterogeneous social realities to which they must respond.

On the other hand, social services require a high degree of interoperability with other administrations (health information systems, social security, employment, housing, finance, municipal census, among others). All these sources of administrative information on users add to the complexity of social issues and the uncertainty that comes with the uniqueness of each situation analysed, which, although similar, will never be the same as another, and the need to seek viable solutions[186]. Faced with this complexity, some administrations have implemented innovative solutions based on Artificial Technology tools and Big Data (see Figure 32).

185 Vallejo Andrada, A., Martí García, S., Gómez Rasco, T., & Ferri Fuentevilla, E. (2024). Aportaciones y limitaciones de la incorporación de la inteligencia artificial a los servicios sociales: Una revisión sistematizada. *Methaodos Revista de Ciencias Sociales*, 12(2), 1–16. https://doi.org/10.17502/mrcs.v12i2.812

186 Minguijon, J., & Serrano-Martinez, C. (2022). La Inteligencia Artificial en los Servicios Sociales: estado de la cuestión y posibles desarrollos futuros. *Cuadernos de Trabajo Social*, 35(2), 319–329. https://doi.org/10.5209/cuts.78747

FIGURE 32. DIGITAL SOLUTIONS IN THE DELIVERY AND MANAGEMENT OF SOCIAL SERVICES

Digital Social Card (TSD)

In 2018, the Government of Spain created the Digital Social Card (TSD) in order to coordinate and improve social protection policies promoted by different administrations. The TSD creates an information system for economic benefits of a social nature managed by the Public Administrations at all three levels, whether they are basic or supplementary, contributory, non-contributory or assistance pensions, temporary benefits such as temporary disability benefits, childbirth and child care, risk during pregnancy and breastfeeding, family protection, Minimum Living Allowance, integration income, or single-payment benefits or aid. It is, therefore, an information platform that aims to provide a service to both citizens, by reducing administrative burdens and simplifying procedures for accessing social benefits; and to the administrations responsible for managing benefits, which will have a comprehensive view of the social protection received by each citizen, which will facilitate more agile and secure procedures for the recognition of rights and for the control of the benefits and aid granted.

Although this is a technological innovation that should simplify information to citizens on the set of benefits to which they have access, their management and the obligations they entail, after more than five years following its creation, there is no information available on the implementation process. In this regard, in 2023, AIReF[187] pointed out the importance of the Autonomous Communities in speeding up the uniform and complete transfer of information on public benefits and especially on regional minimum incomes by coordinating the information in the AEAT databases with that of the INSS Digital Social Card register.

The Siso Big Data system of Castile-La Mancha

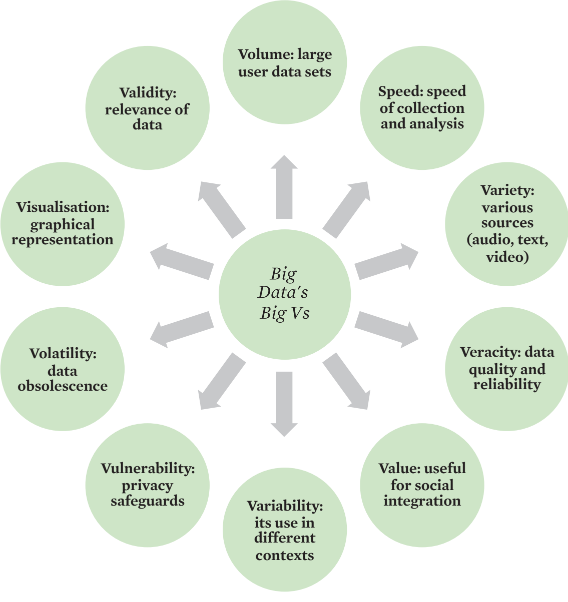
In 2017, the Government of Castile-La Mancha, in collaboration with the University of La Rioja and with funding from the European Social Fund for Castile-La Mancha, designed the SiSo (Social Situation) tool, which was implemented in 2018. It was intended to provide social service professionals and social inclusion organisations with a technological tool to assess complex situations.

SiSo measures social inclusion through six dimensions: economic, employment, education, housing, health and relationships, and classifies situations via a scoring system with four levels of intensity in terms of social difficulty: little or none; some; considerable; and a great deal. Once the data is entered in the tool, it generates a report with a graphical representation of the situation and level of difficulty of the household at the time of the intervention. These data are subsequently analysed to produce valuable information for decision-making, formulation and evaluation of social policies, the management of social inclusion programmes and the production of scientific knowledge useful in responding to social problems[188].

187 Autoridad Independiente de Responsabilidad Fiscal. (2023), *2.ª Opinión. Ingreso Mínimo Vital*, Opinion 2/2023, AIReF.

188 Raya Diez, E. et. al. Op. cit.

GRAPH 21. BIG DATA ASSESSMENT CRITERIA IN THE FIELD OF SOCIAL SERVICES.



Source: Raya Diez, E., Trujillo Carmona, M., & Carbonero Muñoz, D. (2021). Using Big Data to Manage Social Inclusion Programs. *The Journal of Sociology & Social Welfare*, 48(3), 74–98.

However, beyond the need for large amounts of data to improve the effectiveness of social programmes at the individual level, processes of data collection, processing and usage are also important, so that social service professionals know how to handle this information in an effective and equitable manner, while the authorities responsible for policy design and evaluation have the most information available for policy development and innovation, always within the framework of transparency, proportionality and necessity established by current data protection regulations. In other words, data is not an end in itself, but must be useful, representative and of good quality (Graph 21).

As already anticipated, approaching the reality of AI usage in public administrations as a whole is highly complex, and cases may vary widely. It is sufficient to provide certain examples of its usefulness in improving access to social benefits and services, as has been done in the case of social security. It is important to underline the importance of making visible and sharing the solutions that are being implemented in different government bodies and levels of administration, in order to achieve synergies and a coordinated approach to the actions that are being carried out under the principles of good algorithmic governance referred to above. For example, the potential for improved management and access to social benefits associated with the creation of the digital social card in 2018. Other regional experiences, such as the SISO system in Castile-La Mancha, go one step further in implementing technological tools to facilitate the social assessment tasks of professionals in the sector.

Artificial Intelligence in the management of welfare benefits

Unlike Social Security contributory benefits, which are characterised by the increasing speed with which they are granted, and automatic revocation when a person finds a job, benefits for the most vulnerable groups, especially Minimum Living Allowance, regional minimum incomes or dependency benefits, have significantly high rates of non-coverage or the prolonged application processing times.

One of the most striking examples of this is the Minimum Living Allowance (MVI). Almost five years after it came into force, the latest assessment by AIReF[189] continues to point out that the benefit take-up rate is less than 50% and that the average waiting time for the resolution of cases in 2023 was 141 days, even though it has fallen.

Within a scenario of low coverage rates and long waiting times, the recent report published by the Spanish Government's National Office of Foresight and Strategy[190] points out that AI will enable a more efficient public administration by increasing accuracy and speed in the granting of benefits such as the IMV, or by identifying situations of risk of social exclusion, among other applications. These innovations will not only make such policies more efficient and effective, reducing the administrative burden on social services in the case of minimum incomes and on social security management units in the case of the Minimum Living Allowance, but will also considerably reduce the threshold of uncertainty for users in a situation of economic vulnerability awaiting last-resort benefits.

At the same time, the incorporation of this type of tool in the management of social benefits or services should contribute to compliance with Article 28.2 of Act 39/2015, of 1st October, on the Common Administrative Procedure of Public Administrations, which recognises the right of citizens not to provide documents that are already in the possession of the acting Administration or have been drawn up by any other Administration.

3. AI as a key element of the ecological transition

The instruments for the organisation and planning of technological change, and specifically of generative AI, demonstrate the need to assume an environmentally friendly perspective in compliance with and application of European regulations and in line with scientific research on the subject, which is still scarce and of an approximate nature[191].

189 Autoridad Independiente de Responsabilidad Fiscal. (2024), *3.ª Opinión. Ingreso Mínimo Vital*, Opinion 2/2024, AIReF.

190 National Office of Foresight and Strategy. (2025). *HispanIA 2040: How artificial intelligence will improve our future*. Government of Spain.

191 United Nations Environment Programme, *Artificial intelligence (AI) end-to-end. The environmental impact of the full AI life cycle needs to be comprehensively assessed* (Issues note, 21/09/2024). Commission Implementing Regulation (EU) 2025/454 of 7 March 2025 laying down the rules for the application of Regulation (EU) 2024/1689 of the European Parliament and of the Council as regards the establishment of a scientific panel of independent experts in the field of artificial intelligence.

In Spain, the National Green Algorithms Programme[192] faces the challenge of developing technological solutions for the efficient use of resources, minimising environmental impact and energy consumption, thus following the principle of not causing significant damage to the environment. The National Artificial Intelligence Strategy 2024 seeks to place Spain at the forefront of the efficient use of computing infrastructures and the development of sustainable AI, by regulating the sustainable installation of data processing centres (DPCs), as well as obtaining a seal of quality at different levels of progress with regard to sustainable AI.

AI, facilitating SDGs

In general terms, AI is seen as an enabler rather than an inhibitor of sustainable development, acting positively on 134 SDG indicators and negatively on 59 others. Specifically, 67 indicators included in the category of social SDGs (82 per cent) benefit from AI, 42 (70 per cent) in the economic ones, and 25 in the group of environmental ones (93 per cent), related to the possibility of analysing large-scale interconnected databases and developing joint actions aimed at environmental preservation, such as climate action (SDG 13), through the integration of renewable energy and energy efficiency, the conservation of marine resources and combating its pollution (SDG 14), or the fight against desertification and soil degradation (SDG 15)[193].

3.1. OPPORTUNITIES FROM THE POINT OF VIEW OF THE URBAN AND RURAL AGENDAS

As previously mentioned, the influence of new technologies on multiple aspects of well-being is unquestionable, and this makes it necessary to link sustainable human development with the knowledge society in the framework of the so-called *smart cities*[194]. While there is no single definition of a smart city, the term refers to a set of initiatives aimed at using digital technologies, including AI, to improve the quality of urban life. This is a broader concept than "digital city", as it requires governance mechanisms for technological advances in data transformation processes so that it is accessible to citizens. Within this context, AI can provide solutions in different areas of management, from optimising and facilitating decision-making to the implementation of services, generating economic opportunities, increasing efficiency, and boosting democratic participation and environmental sustainability[195].

Towards technological and sustainable urban development

And this is already happening. In terms of access to information, the Spanish Urban Agenda 2024 offers a panorama of urban and rural realities through socio-de-

192 Miteco, National Green Algorithms Programme (Digital Spain Agenda 2026, 13/12/2022, https://portal.mineco.gob.es/es-es/comunicacion/Paginas/algoritmos-verdes.aspx).

193 Nature Communications, The role of artificial intelligence in achieving the Sustainable Development Goals (13/01/2020 https://www.nature.com/articles/s41467-019-14108-y)

194 Spanish Urban Agenda 2019, Strategic Goal 9: Lead and promote digital innovation.

195 European Parliament, Research for REGI Committee – Artificial Intelligence and Urban Development (30/07/2021).

FIGURE 33. APPLICATIONS (LEFT) AND GOOD PRACTICES (RIGHT) OF AI

INTELLIGENT MOBILITY

Traffic management: real-time data analysis allows the prediction of traffic jam patterns and pre-emptive trafficdiversion. Intelligent traffic light coordination to maintain constant traffic flow, control of reversible lanes and express lanes.

Road Safety: prediction of accident probability, travel volume and route safety. It is expected that driver assistance systems in intelligent vehicles which are capable of analysing the environment and making immediate decisions, will be developed.

PUBLIC SECURITY

Security cameras: continuous surveillance allows for the detection of potential dangers and rapid responses. Prohibition of applications that infringe on citizens' rights, such as biometric categorisation systems based on sensitive characteristics and indiscriminate capture of facial images or recordings from surveillance cameras to generate facial recognition databases.

Early detection of natural disasters early detection of natural disasters: forest fires, earthquakes or floods, providing a rapid and effective response.

SUSTAINABLE CITIES

Waste management waste identification and classification with 72.8 to 99.9% accuracy. Quality tracing of sorted material, determination of bag composition or detection of sorting performance problems. Container filling control by means of sensors and smart cameras, sending alerts to collection teams when a certain threshold is reached.

Energy efficiency optimising the energy consumption of buildings; equipping public spaces with smart lighting that can be adapted to different conditions and requirements, improving safety in urban areas

SMART AGRICULTURE AND BIODIVERSITY CONSERVATION

Real-time crop monitoring to identify diseases and optimise the use of water and fertilisers

Habitat monitoring, wildlife protection, species pattern recognition.

Urbact: European database of local good practices on sustainable urban development: 116 initiatives in sustainable mobility, energy, public participation, digital skills, transport on demand or recycling (16 Spanish).

Citcom.AI: European project Smart Cities & Communities, focused on reducing energy consumption, efficient and sustainable transport, and public services of interconnected local infrastructures. Valencia hosts the South Supernode of Artificial Intelligence (AI) applied to smart cities.

RETECH (Territorial Networks of Technological Specialisation): an initiative of the State Secretariat for Digitalisation and AI, aimed at reducing the regional divide, transformation and digital specialisation, fostering leadership and inter-regional cooperation in promoting projects with a territorial and economic impact, generatingor promoting disruptive initiatives based on regional experiences and knowledge, and promotingregional actions to boost the move towards sustainable and inclusive development models. Launch 24 March 2023. Flagship projects:

- **Spain Living Lab (AI Mission):** AI development in the tourism sector
- **Artificial Intelligence Value Chain:** AI development in the industrial business sector
- **Territorial Network of Artificial Intelligence Hubs (Value Chain):** AI development in new educational itineraries
- **TechFabLab (Entrepreneurship Networks):** support for local AI initiatives
- **Networked Agri-FoodPlatform:** AI applied to the agri-food sector
- **Infrastructure for the Spanish Blockchain Network:** creation of a technological network based on Blockchain
- **Acceleration of entrepreneurship and innovation ecosystems based on Digital Twins:** virtual recreations of the region for predictions and simulations
- **Project for the Digitalisation and Artificial Intelligence of the Prehistoric Heritage of Cantabria and Asturias:** optimisation of prehistoric heritage management .
- **Digital Entrepreneurship Networks:** innovative regional solutions based on AI
- **Intelligent Digital Health:** healthcarerobotics in the medical sector
- **RETECHFOR:** Territorial Technological Network of the forestry sector.
- **Knowledge Heritage Network:** development of a cultural heritage data collection platform.
- **Entrepreneurial ecosystem for a smart rural and marine territory (TriRuralTech):** fostering entrepreneurship in rural areas

Source: Author's own based on data from the Digital Public Administration (https://www.administracionpublicadigital.es/tecnologias/2024/09/asi-es-como-la-inteligencia-artificial-esta-transformando-la-gestion-urbana) and PRTR (https://planderecuperacion.gob.es/noticias/conoce-programa-retech-redes-territoriales-especializacion-tecnologica-plan-recuperacion).

mographic and economic data, in order to facilitate comparisons between municipalities and generating accessible information that translates into descriptive applications (maps or graphs). This is the case of the Urban Information System (SIU)[196], which offers free urban information on 5,683 municipalities inhabited by 98.3 percent of the population, together with other information of interest in the field of decision-making and urban planning, for example, on land occupation and its evolution through the CORINE Land Cover (CLC) and the Spanish Land Occupation System (SIOSE) projects, or on areas at risk of flooding and earthquakes.

The technological combination offered by AI can be used in the design of efficient, sustainable and liveable cities, anticipating the needs of the population and adapting to changes in real time, in what is known as predictive urban planning. New smart city models would be used to optimise everything from traffic flow to resource allocation by simulating behaviour through intelligent agents. The energy management of buildings, the development of self-repairing energy systems for the security of electricity supply or digital twins to optimise urban dynamics (provision of services, predictive traffic, emergency situations, etc.), are among its most sought-after applications (Figure 33).

Many of these applications are also aimed at reducing GHG emissions and better adaptation to climate change, such as the GreenTech projects (accelerators of a sustainable and climate-neutral economy), RetechFor (aimed at forest monitoring and environmental disaster reduction), or RuralTech (which aims to achieve an intelligent rural and marine territory) (Figure 33).

3.2. ENVIRONMENTAL CHALLENGES AND POSSIBLE SOLUTIONS

Although the progressive incorporation of AI is helping to reduce the environmental footprint in various areas, the negative impact of generative AI activity itself is significant, and especially critical due to the exponential increase in advanced models, which are responsible for high consumption of electricity, water and materials, and GHG emissions. They also lead to an unequal distribution of the environmental impacts associated with their implementation. These challenges underline the need for a sustainable and ethical approach to the research, design and use of these technologies.

Research on the Environmental Footprint of Generative AI, as yet insufficient

The environmental impact of AI occurs throughout its entire life cycle, and not only during the training phase as previously believed, which requires an analysis at each stage of the process that can measure direct impacts (con-

196 New layers of importance to urban planning and territorial analysis have recently been added to the SIU viewer: Land Planning instruments, Territorial Waters service, River Flood Risk services, Radon Concentration Map in Spain (Nuclear Safety Council) as well as new CORINE Land Cover information, corresponding to 2012 and 2018 with their variations, and SIOSE 2014 information (Ministry of Housing and Urban Planning – Descriptive Data of the Spanish Urban Agenda 2024 and https://www.mivau.gob.es/urbanismo-y-suelo/sistema-de-informacion-urbana). Digital Atlas of Urban Areas (https://atlasau.mitma.gob.es/#c=home).

FIGURE 34. ENVIRONMENTAL IMPACT OF AI

ENERGY CONSUMPTION: data centres (DCs).	Energy consumption: between 10% and 20% of the total, which can increase to 70% Electricity consumption: between 2 and 3% of the total (usa) They use 40-50% of their energy to power servers and 30-40% to cool them Renewables are expected to cover 40% of their energy demand.
GHG EMISSIONS (estimated): AI training stages.	Equipment manufacturing: 22.2% of the total (11.2 tonnes CO_2). Dynamic consumption: 48.9% (24.69 tonnes CO_2). Inactive consumption: 28.9% (14.6 tonnes CO_2). Construction of DCs: up to 8% of global CO_2 emissions.
INTENSIVE WATER CONSUMPTION: In DCs	DCs can use between 0.18 and 1.1 litres of water per kWh of energy consumed. On average, a hyperscale DC can use up to 2.1 million litres of water per day. GPT-3 consumes about 500 ml of water for every 10 to 50 queries; Taiwan Semiconductor Manufacturing Company (TSMC), uses 157,000 tons of water/day CHALLENGES: - Depletion of local resources: pressure on water resources in arid areas (Arizona Desert) - Competition for clean water supply
MINERAL CONSUMPTION: in manufacturing semiconductors for GPUs and CPUs.	Silicon: main component, to which other metals and minerals are added in order to improve itsconductivity and durability: - base metals: aluminium and copper; - rare and strategic ores: tantalum, lithium, gallium, germanium, cobalt, palladium and tungsten. CHALLENGES: - Intensive extraction: hundreds of tonnes of rock must be processed per tonne of pure ore, - Conflict minerals: cobalt and tungsten come from regions affected by armed conflict.

Note: GPUs (graphics processing unit) and CPUs (central processing unit),
Source: Authors' own based on Miteco, National Green Algorithms Programme.

sumption of energy, water and minerals, and generation of waste and emissions) and indirect impacts (e.g. potential increase in the use of autonomous vehicles), as well as others derived from possible changes in consumption and production patterns, risk of misinformation or inadequate governance, among others (Figure 34).

Research in this field is still preliminary, leading to the publication of unverified data by some media. In this regard, UNEP recommends standardising measurement systems and making metrics transparent and accessible, prioritising research aimed at optimising energy-efficient algorithms and reducing carbon emissions[197].

Some aspects, such as water consumption, are especially critical in countries such as Spain with a water deficit, which annually consumes 30.8 thousand hm^3, with gross demand extracting just over 30 percent of the national natural resource[198]. In this re-

197 UNEP Issues note, 21/09/2024 (op.cit).
198 Miteco, Usos del agua en España 2021-22 (December 2023).

gard, the European Union has adopted a delegated regulation to establish a scheme capable of measuring the sustainability of data centres, for example through the publication of water footprint data[199].

Unequal distribution of impacts: environmental inequity

AI developments are usually based on the needs and values of the countries in which they occur, with the risk of adopting approaches that lack ethics, transparency or democratic control, and their potentially negative effects on socio-economic and territorial cohesion are as yet unknown. These developments will be more rapid in regions and sectors with greater access to technology, with some disparities within and between countries likely to be exacerbated.

Environmental inequity is deeply linked to socio-economic divergence, causing disproportionate impacts on already marginalised communities, such as increased air pollution and reduced freshwater resources. A geographical distribution of data centre networks that prioritises disadvantaged regions and evenly distributes the negative impact associated with such activity would increase territorial load balancing by redirecting AI traffic (Figure 35).

To avoid such unintended consequences, progress must be made in reducing the emerging socio-economic and environmental divide by promoting responsible AI that mitigates inter-regional disparity. The impacts of these inequalities are often not evident or visible to most citizens, therefore raising awareness in public and private spheres is key. A fair distribution of the benefits of AI would lead to an effective redistribution of regional environmental costs, driving more equitable outcomes.

In conclusion

There is still some way to go before we can reap the benefits of AI and maximise its positive social impact, especially in the management of public procedures, benefits and services with an impact on people's rights.

It is necessary to promote the development of the most suitable instruments for this purpose, such as the creation of public registers of algorithms; conducting regular independent audits to prevent, identify and correct possible biases and errors; promote transparency and public participation in the assessment and improvement of these systems; and make progress in developing a clear regulatory framework for the ethical and responsible use of algorithms, guaranteeing equality and citizens' rights.

199 European Commission, Commission Delegated Regulation (EU) 2024/1364 of 14 March 2024 on the first phase of the establishment of a common Union rating scheme for data centres (C(2024) 1639 final).

FIGURE 35. RECOMMENDATIONS FOR ENVIRONMENTALLY EQUITABLE AI

Geographical load sharing

Make AI deployment and managementmore flexible through geographically distributed data centres (DCs), prioritising marginalised regions and distributing negative environmental impacts equitably.

- Balancing loads by diverting AI traffic considering real-time local factors, such as the proportion of fossil energy sources and water use efficiency.
- Apply regardless of where a company operates, whether on its geographically distributed infrastructures and DCs or via cloud-based services.

CHALLENGES

- Predicting future AI demands to justify long-term environmental impact.
- Ensuring a consistent level of model performance and inference quality (predictability).

Environment and ecosystems

- Measuring direct and indirect environmental impacts throughout the life cycle of AI systems, including carbon footprint, energy consumption and environmental impact of raw material extraction, and reducing the environmental impact of AI systems and data centres.
- Introducing incentives to ensure the development and adoption of human rights-based and ethicalsolutions to AI systems to address risks of natural disasters. These AI systems must involve the participation of local and indigenous communities throughout their life cycle and support a circular economy approach and sustainable consumption. Applications include:
  a. protection, monitoring and management of natural resources
  b. prediction, prevention, control and mitigation of climate-related problems
  c. conservation of a more efficient and sustainable food ecosystem
  d. boosting access to mass adoption of sustainable energy.
  e. enabling and promoting the dominance of infrastructure, business models and finance for sustainable development.
  f. detection of pollutants or prediction of pollution levels by assisting in the identification of relevant stakeholders, planning and implementing interventions to prevent and reduce pollution and exposure to pollution.
- When choosing AI methods, given the scale of the environmental impact associated with some of them, it should be ensured that stakeholders favour efficient AI methods of data processing and energy and resource consumption. Requirements should be put in place to ensure the availability of evidence in this regard, and failing this, the precautionary principle should be favoured, so that AI is not used in instances where the environmental impact is disproportionately negative.

Source: Harvard Business Review Management, The Unequal Distribution of the Environmental Impacts of AI (26/07/2024) and UNESCO, Recommendation on the Ethics of Artificial Intelligence (23/11/2021).

FIGURE 36. SOCIAL IMPACTS OF ARTIFICIAL INTELLIGENCE

People-centred digitalisation and artificial intelligence

AI represents a historic opportunity to improve the well-being of people, the sustainability of the planet, and the achievement of the goals of the 2030 Agenda. It has enormous potential to improve the quality and personalisation of public services, to detect social problems more accurately, to make data-driven decisions, to improve the efficiency and evaluation of public policies, to streamline procedures, and to reduce costs. However, AI systems pose certain risks in the area of fundamental rights, environmental protection or the fight against climate change, amongst other social impacts, generating uncertainties around liability issues.

Public opinion reflects this tension between the transformational potential attributed to AI and caution regarding its consequences, challenging public authorities on the need to guarantee certain rights.

THE NEED FOR SAFE, RELIABLE AND HUMAN-CENTRED AI

The principles of humanity, prevention of harm, fairness and explainability of AI systems are advocated by international bodies, determining the limits of the development, deployment and use of reliable AI. Reliability requirements are summarised in the need for human action and oversight, technical soundness and security, privacy and data management, transparency, diversity, non-discrimination and equity, environmental and social well-being and accountability.

From this perspective, the new EU AI Law is a major step forward, introducing specific legal obligations graded according to the risks posed by each AI system to citizens' rights, prohibiting those that represent an unacceptable risk. The AI Law regulates especially sensitive sectors, such as health, education, justice and public administration, employment and human resources, and security and safety. However, it excludes socially relevant sectors from the obligation to make a prior assessment

Source: European Commission.

ALGORITHMIC GOVERNANCE, TRANSPARENCY AND ACCOUNTABILITY

Algorithmic transparency implies that the factors involved in the decisions made by algorithms should be visible, knowable, auditable and explainable to the people who use, regulate, and are affected by the systems that employ these algorithms. Lack of transparency can result in systemic errors which in turn lead to unfair decisions and erode public confidence in institutions. Therefore, public administrations should be a benchmark for algorithmic transparency.

The creation of public registers of algorithms would enable citizens to be aware of the systems that are being used, their purposes and potential impacts, building trust and facilitating the monitoring and auditing of these systems. However, there is as yet no statewide registry or homogeneous protocol for the creation of algorithm registries. Its development presents a fragmented picture, with uneven progress between administrations, although there are already some pioneering experiences.

Clear regulation of responsibility and accountability is necessary to ensure the right of citizens to appeal automated decisions that adversely affect them. An opportunity in this area may be in the form of the draft bill for the proper use of Artificial Intelligence.

TOWARDS NON-DISCRIMINATORY AI: A SPECIFIC LOOK AT GENDER BIASES

Preventive, proactive and ethical approaches are needed to develop and implement AI systems, so that algorithms do not simply replicate and magnify existing biases in society by complying with the principles of non-discrimination and establishing monitoring and control mechanisms.

Imbalances in female representation in AI or the assumption of gender stereotypes in their training can increase discrimination and prejudice. Reducing gender bias in the design, development and implementation of AI needs to be addressed through a comprehensive approach that combines enforcement, independent audits, encouraging greater participation of women, and the inclusion of a gender perspective in all phases of data engineering.

Other risks of bias, such as ageism, also require assessment and prevention.

FIGURE 36. SOCIAL IMPACTS OF ARTIFICIAL INTELLIGENCE (*continuation*)

AI as a key element of the ecological transition	
Opportunities	***Challenges***
AI is seen as an enabler rather than an inhibitor of sustainable development, acting positively on 134 SDG indicators and negatively on 59 others. Within the context of urban development, and more specifically in the shaping of so-called smart cities, AI can improve the quality of life by providing governance mechanisms for technological advances in the process of data transformation, and offer solutions in different areas of management, generating economic opportunities, increasing efficiency and boosting democratic participation and environmental sustainability. The technological combination offered by AI can be used in the design of efficient, sustainable and liveable cities, anticipating the needs of the population and adapting to changes in real time, in what is known as predictive urbanism. New smart city models would be used to optimise everything from traffic flow to resource allocation by simulating behaviour through intelligent agents.	However, the negative impact associated with generative AI activity itself is especially critical due to the exponential increase in advanced models, which are responsible for high energy, water and material consumption and GHG emissions. They also lead to an unequal distribution of the environmental impacts associated with their implementation. These challenges underline the need for a sustainable and ethical approach to the research, design and use of these technologies. To avoid the unintended consequences of environmental impacts, progress must be made in reducing the emerging socio-economic and environmental divide by promoting responsible AI that mitigates inter-regional disparity. A fair distribution of the benefits of AI would lead to an effective redistribution of regional environmental costs, driving more equitable outcomes.

Impact of AI on welfare and social protection policies		
Education	**Opportunities**	Automating the basic levels of creation enables learning and teaching processes to be freed from lower-order tasks and to focus on more complex ones. It facilitates the presentation and visualisation of results. It reduces the amount of teaching time spent on more routine and management tasks in order to focus more on the development of content and teaching methods, and to provide more personalised attention to students. It could support the adaptation of education to students with special needs.
	Challenges	It may generate erroneous or biased content, as well as offensive, discriminatory or unethical content. Moreover, it does not always provide adequate answers to many real-world problems. It can amplify issues related to inequality, digital poverty or the risk of exclusion of digitally poor students or schools, as well as lack of content related to local issues or minority populations or languages. It raises important challenges related to the security and reliability of results, data privacy, copyright and others. Teachers require training and skills regarding the basic concepts of AI (teaching about AI), on the challenges and opportunities of the use of AI tools for learning (teaching for AI), and on their application in the educational context (teaching with AI). Education systems and lifelong learning programmes need to equip students with the skills to harness the benefits of AI and manage the risks associated with it on the basis of ethical and humanistic values as well as critical thinking. Since AI progress is unstoppable, it is important that measures continue to be taken in parallel with its growth and the improvement of tools. Ongoing evaluations of the impacts of AI in education are required in order to understand the real benefits and problems it generates in the field of teaching and learning. There is a need to establish mechanisms for collaboration and governance between the different stakeholders involved in the education sector.

FIGURE 36. SOCIAL IMPACTS OF ARTIFICIAL INTELLIGENCE (*continuation*)

Impact of AI on welfare and social protection policies		
The use of AI and big data in Social Security management	**Opportunities**	The huge volume of data and administrative processes generated by Social Security and the fact that it is one of the administrations closest to the citizens makes it an especially favourable environment for the adoption of technologies based on AI and Big Data. Thus, for some years now, different tools have been used, mainly aimed at automating processes, optimising resources and providing services. The goal should be to improve the efficiency of the system - by reducing costs and administrative burdens -, to streamline benefits management - by reducing waiting times and optimising planning - and to allocate resources according to the real needs of the population and future trends.
	Challenges	Despite its many benefits, implementing AI in Social Security also poses significant challenges in terms of data protection and privacy of citizens' information, fairness and transparency in automated decision-making, the adaptation of public employees to its use, or the exclusion of those who lack the knowledge and/or resources to access and use the necessary technologies. A robust regulatory framework in this area and effective human oversight are essential to ensure ethical, transparent and equitable use of AI, avoiding biases and risks and guaranteeing citizens' rights.
AI, a bridge to more inclusive social services and benefits	**Opportunities**	The massive use of data, its inter-administrative connections and the deployment of artificial intelligence tools provide social services professionals, as well as those who formulate and plan protection and support policies for vulnerable populations, with in-depth, up-to-date and accurate empirical knowledge regarding the real needs of the population. This expanded knowledge not only makes it possible to detect existing shortcomings or gaps more quickly, but also becomes a key instrument for designing more effective, equitable and better targeted social interventions and benefits that are more responsive to changing social realities.
	Challenges	The inclusion of AI tools in contexts marked by professional and structural overload, with the aim of increasing efficiency, improving effectiveness, reducing administrative burdens or automating processes for granting benefits, entails the risk of generating undesired effects contrary to the initial objectives. In the absence of adequate mechanisms for transparency, data traceability or algorithmic monitoring, these technologies can lead, as has already happened in different areas, to opaque or unfair decisions that may be perpetuated over time. This affects fundamental rights such as personal data protection, privacy, security, equality and non-discrimination, as well as equal access to social assistance and public benefits. All of this may also contribute to a progressive erosion of public confidence in institutions.

CONCLUSION:

There is still some way to go before we can reap the benefits of AI and maximise its positive social impact, especially in the management of public procedures, benefits and services with an impact on people's rights. It is necessary to promote the development of the most suitable instruments for this purpose, such as the creation of public registers of algorithms; conducting regular independent audits to prevent, identify and correct possible biases and errors; promote transparency and public participation in the assessment and improvement of these systems; and make progress in developing a clear regulatory framework for the ethical and responsible use of algorithms, guaranteeing equity and citizens' rights. It is especially necessary to promote training and education, so that the largest number of people are aware of reliable AI and receive training in this field. In this way, the development of this technology will contribute to reducing rather than deepening existing social gaps.

Source: Authors' own.