FURN5.0

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D2.1 - Industry 5.0 in Europe

What it is, where it comes from, where it is, where it is going

WP2

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SUMMARY

1. Introduction

Industry 5.0: a real revolution or just an evolution?

What concepts is the new 5.0 paradigm based on? What are the real possibilities that open for European manufacturing companies? How can we exploit the new opportunities that Industry 5.0 brings with it to increase the competitiveness of the European economy?

These are the fundamental questions from which this research starts, which is mainly based on existing specialist literature and institutional sources, to identify global trends at European level and for the various national economies.

The research aims to illustrate the contents of Transition 5.0 in its inspiring principles and purposes: the transition from Industry 4.0 to the dual Transition (Digital and Ecological) 5.0.

This step is essential to fully understand the challenge launched by this new "transition" so as not to underestimate its scope, cataloguing it as a simple revisitation of Industry 4.0. The transition to Industry 5.0 wants to be much more, at least in its inspiring principles. For its practical implementation, however, the different countries are questioning themselves and are starting to take measures and undertake actions to stimulate the implementation of these new guidelines. It is therefore interesting to understand what the challenges and risks are for the European economy, as well as trying to imagine the possible expected repercussions on national economies, which will depend greatly on the different implementation methods that the countries will choose in the months to come. Starting from some data at European level, we will try to paint a picture of the possible developments of the European economy and in the different countries, also outlining the major challenges and the great risks that the 5.0 transition brings with it.

2. Industry 5.0. What are we talking about?

Socio-industrial revolutions have always had one thing in common: aiming to change production processes. They also have the same objectives, which have always been the driving force of innovation: greater productivity, increased flexibility and optimization of value creation processes.

Industry 1.0 represents the transition from muscle power to energy physically generated by steam and water. Industry 2.0 marks the beginning of mass production, with the help of electricity, while Industry 3.0 outlines the era of computerized automation, which since the 1970s has given a strong boost to the growth of productivity and flexibility.

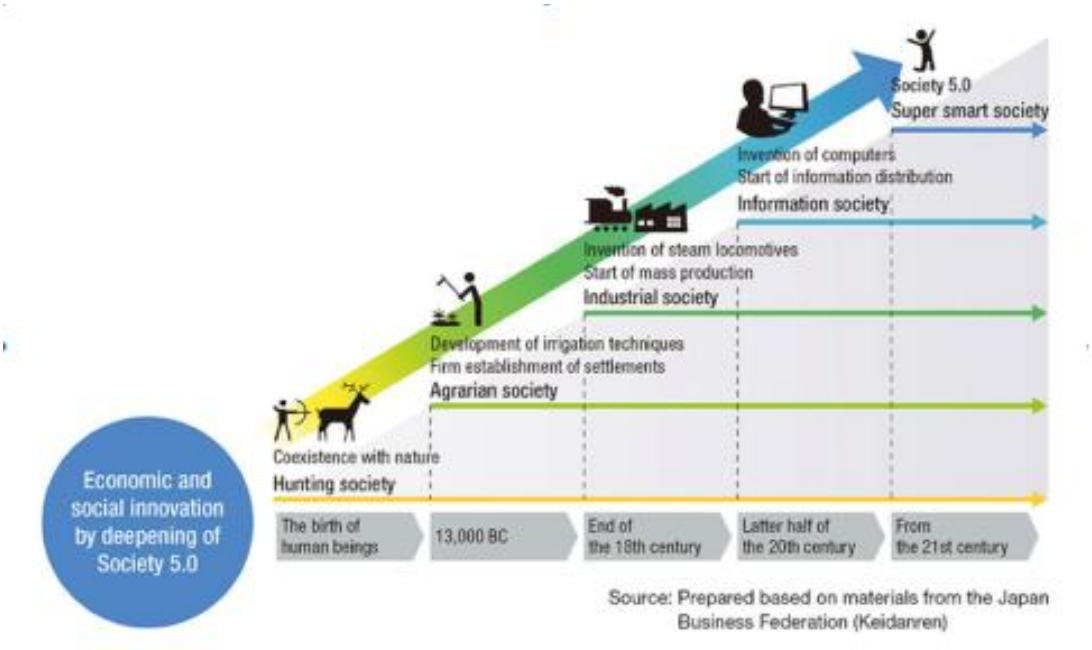
This has led to Industry 4.0, the cradle of all the new opportunities offered by the digital connection of production in the various phases of assembly, maintenance, repair, marketing and disposal. Machinery and components are no longer simply networked and centrally controlled, as in Industry 3.0, but are also able to make autonomous decisions, in a decentralized way, based on digital information, then integrating them into the overall production system.

The enormous volumes of data that can be stored and analyzed as big data allow us to develop predictions on how to improve the efficiency, reliability and safety of production processes, going well beyond the mere exercise of reading a crystal ball. A transformation that brings intelligence into the factory, enabling truly smart management of resources and all company processes.

And this intelligence is the starting point for winning another great challenge for industry: that of sustainability.

The challenge now is to put 4.0 technologies at the service of a production model capable of promoting the creation of value in increasingly difficult and volatile contexts. A strong industry capable of withstanding economic crises and capable of responding to major environmental and social challenges. In short, a more resilient, sustainable and human-centered industry.

This is how we talk about Industry 5.0. A new model of Industry that does not break with the past, but builds on what was built by Industry 4.0.



For companies, this is a further challenge, as this transformation originates and has repercussions well outside the industry and encompasses transversal themes: from a different use of the resources needed for production, to a sustainable management of the entire life cycle of products, to changes in relationships with market stakeholders (customers, competitors, regulators, workforce).

As happened for the fourth industrial revolution, Industry 5.0 also requires a paradigm shift that must embrace the entire organization, starting from the culture and values that animate it. Challenges that, if adequately addressed, enable significant advantages: from cost reduction (associated with more efficient management of processes, based on automation technologies) to greater flexibility at the factory level, up to new services based on the circular economy.

Industry 5.0 refers to an industrial model based on three principles, or "pillars": sustainability, human-centrism, and resilience.

The difficulty of framing Industry 5.0 within the evolutionary history of industry arises from the fact that some of the "promises" of this industrial model had already been conceptualized within the paradigms of Industry 4.0.

Already with the advent of the Fourth Industrial Revolution, in fact, the automation of processes was aimed at enabling important benefits for the company, but also at freeing man from burdensome and repetitive tasks, to enhance that "creative spark" that distinguishes him from machines.

3. Link between Industry 4.0 and Industry 5.0

The automation of tasks traditionally performed by operators has in fact improved working conditions with a view to enhancing the value of the operator and improving safety within plants.

At the same time, devices and solutions based on the Internet of Things (IoT) and Artificial Intelligence (AI) have made it possible to bring intelligence into machines and components used in processes.

Based on the analysis of the reported data, companies that have already undertaken this transformation have been able to enable important benefits, such as:

- The transition from reactive or preventive maintenance models to predictive maintenance which, based on machine or component performance indicators, allows intervention when really needed (preventing downtime) and smarter management of spare parts ordering.
- The analysis of energy consumption, which makes it possible to implement, based on data from efficiency strategies, a reduction in production waste.
- More efficient and flexible process planning (from production to logistics), based on changes in demand or production needs.
- Data sharing with all relevant stakeholders, within the company and along the supply chain for integrated, collaborative and efficient processes digitalization of corporate knowledge.

Transformations that have already enabled companies to reduce the environmental impact of processes and to involve the workforce more actively, thanks to automation solutions that are easier to configure and use. Even on the technological front, the transition between Industry 4.0 and Industry 5.0 does not see the break, or the leap, which was seen in the transition, for example, from Industry 3.0 to Industry 4.0.

The enabling technologies for this new phase of Industry are in fact already present in companies that are well along the digitalization path.

These technologies, as identified by the European Commission* in a policy briefing focusing precisely on Industry 5.0 are:

- customized human-machine interaction.
- nature-inspired technologies and intelligent materials.
- digital twins and simulation.
- technologies for data transmission, storage and analysis.
- artificial intelligence.
- technologies for energy efficiency, renewable energy, energy storage and autonomy.

(Source: Industry 5.0: A Transformative Vision for Europe – European Commission)

So why did we feel the need to start talking about Industry 5.0?
This is explained by the European Commission itself in a second analysis document, specifying that: 'Over the last decade, Europe has gradually intensified its commitment to industrial transformation, especially working on the transition to the so-called Industry 4.0, an essentially technological paradigm, centered on the emergence of cyber-physical objects, which promises greater efficiency through digital connectivity and artificial intelligence. However, the Industry 4.0 paradigm, as currently conceived, is not fit for purpose in a context of climate crisis and planetary emergency, nor does it address deep-seated social tensions. On the contrary, it is structurally aligned with the optimization of business models and economic thinking that underpin the threats we are facing. The current digital economy is a winner-takes-all model that creates technological monopoly and gigantic wealth inequality'.
(Source: Industry 5.0: A Transformative Vision for Europe - European Commission).

The complexity of the challenge is clear from this explanation: the need to move industry into a new era stem from needs that are social as well as economic. What is in question is in fact the economic paradigm at the basis of society, the model that the Commission calls 'winner-takes-all,' based on the pursuit of profit and centered on the 'linear' economic model and declined according to 'take, use, throw' principles.
The disruptions that have affected markets in recent years, as well as the materialization of extreme events linked to climate change, have turned the spotlight on the economic, environmental and social unsustainability of the model on which it is based.
While the maturation of Industry 4.0 technologies and paradigms has shown that it is possible to produce more efficiently, their increasing introduction has prompted stakeholders to question the impacts of such a transformation on society and the environment.
Hence the need to rethink this model and govern the process of digitalization and to decouple it along the principles of a new economic model, the circular one, centered on the 'repair, reuse, recycle' principles. A model where 4.0 technologies play the role of enabler for processes that are more resilient and sustainable and adapted to the operator's needs. If at first the question was what benefits could be enabled by these technologies, the focus now shifts to understanding what these technologies can do for humans.
To understand how this change is realized and the role played by 4.0 technologies, it is necessary to understand what is meant by sustainability and, in particular, by sustainable development.
The definition underpinning modern sustainability policies is that provided by the World Commission on Environment and Development in a report published in 1987. In the document, sustainable development is defined as 'a pattern of development that ensures

that the needs of the present generation are met without compromising the ability of future generations to meet their own needs.' From this definition, it is clear that sustainability has not only an environmental dimension, but also a social one, as it requires that human activities be conducted in the responsible use of resources and with respect for the planet, so as not to harm the rights of future generations.
At the same time, sustainability has an economic dimension in that the generation of profit promotes well-being within society. Any model that is truly sustainable must be able to 'stand the test of time' while fully respecting the environment, human rights and ensuring continued creation of value (and thus well-being) for society as a whole.
(Source: Brundtland Report - World Commission on Environment and Development, 1987).

Industry has a primary task in this transformation. Firstly, it is among the most polluting sectors of the economy: in Italy, manufacturing produces 21.1% of total emissions, with almost 80 million tons of CO2, around 75 million CH4 (methane) and just over 3 million N2O (nitrous oxide).
However, emissions are only one aspect involved in the transformation of industry to a sustainable perspective, as sustainable development requires:

- sustainable use of renewable resources. This means that the rate of use should be less than the rate at which resources are able to regenerate themselves.
- sustainable use of non-renewable resources, i.e. their depletion should be offset by a switch to renewable resources.

It is therefore clear that reducing the environmental impact of industrial processes requires action on all the steps and players in the supply chain: from procurement strategies to product design and production processes, to the management of maintenance and end-of-life operations.
A social responsibility that is attributed to industry precisely by virtue of its role as an agent of value production, as well as employment creation, and that for this reason takes the form both of a responsibility towards its workforce and towards the community in the territory in which the company operates or, in some cases, towards distant communities (e.g. in developing countries), but affected by the inequalities that an unsustainable development model has created.
Indeed, in Industry 5.0, man takes a significant role both because it is not possible to make this leap without the involvement of the workforce and because, as previously explained, Industry 5.0 is the child of changes that are primarily cultural and that embrace different themes.
Among the drivers of change that have brought man to the center of this process we can identify:

- A change in the values that guide the workforce's choices. Years of increased focus on sustainability issues have given rise to a desire in the workforce to value their time and skills in their chosen employment. Their time and skills in their chosen occupation. The pandemic has accelerated this process, turning the spotlight on issues that were already important to the workforce (such as burnout, work-life balance and work flexibility) and showing that other organizational models are already possible, thanks to digital technologies.
- The increasing weight that corporate sustainability policies have on brand perception and market choices.
- The progressive ageing of the workforce in industry, against an increasing difficulty in finding the necessary skills on the market. Automation may, in part, replace outgoing resources, but the competitiveness of the company will depend on its ability to attract and retain talent, to safeguard the know-how acquired by this outgoing workforce and to train internally the skills needed to work in an increasingly hybrid environment.
- Increasingly stringent obligations on the part of regulators regarding corporate responsibility with respect to ESG (Environmental, Social and Governance) issues.

The centrality of humans is not at odds with a vision of the Smart Factory but is on the contrary enabled by Industry 4.0 technologies. The use of Industry 4.0 technologies enables the automation of repetitive and burdensome tasks - from the handling of goods to maintenance checks in remote or of plants - and leaves the operator more time to deal with tasks of higher cognitive value. In a nutshell: automation allows man to harness that creative spark that distinguishes him from machines.

Not only that, technological progress - with the products and services resulting from innovative processes within industry - can offer the means to address important social issues and help reduce inequalities.

A passage from the 2013 Lima Declaration underlines this synergy between technological progress, industry and sustainability: 'Industry increases productivity, job creation and generates income, thereby contributing to poverty eradication and the achievement of other development goals, as well as providing opportunities for social inclusion, including gender equality, the empowerment of women and girls and the creation of decent employment for young people. Industry development fosters increased value addition and improved the application of science, technology and innovation, thereby encouraging greater investment in skills and education and providing the resources to achieve broader, inclusive and sustainable development goals.'

(Source: XX COP20 in Lima, 2013 - Final declaration)

The transition from Industry 4.0 to Industry 5.0 will require reviewing many of the crucial aspects that underpin our production model. The challenge for companies is not to be underestimated, because it must be implemented on many fronts, starting with the corporate culture itself: a more balanced view of value over time must be adopted, including a more balanced view of value over time, encompassing the polyvalent value of human, natural and financial capital.

4. A new vision of industry

The vision for 'Industry 5.0' we propose moves past a narrow and traditional focus on technology-or economic enabled growth of the existing extractive, production and consumption driven economic model to a more transformative view of growth that is focused on human progress and well-being based on reducing and shifting consumption to new forms of sustainable, circular and regenerative economic value creation and equitable prosperity. Rather than representing a technological leap forward, Industry 5.0 actually nests the Industry 4.0 approach in a broader context, providing regenerative purpose and directionality to the technological transformation of industrial production for people-planet-prosperity rather than simply value extraction to benefit shareholders. An Industry 5.0 approach has very important consequences for the EU industrial strategy writ large. It requires new economic orientations to industry performance, new design for business models, value chains and supply chains, new purpose for digital transformation, new approaches to policymaking in partnership with business and industry, new capabilities and approaches to research and innovation as well as vertical and horizontal coherence by acting at all levels of government and through international standards. It addresses recent knowledge and learnings from the COVID pandemic and the fundamental need to build resilience across value chains and secure people's lives and livelihoods whilst living within planetary boundaries. It proposes a very different set of enabling approaches to Europe's so-called "twin transition", intending to connect digital transformation with sustainability and climate action. We explore this below.
In essence, Industry 5.0 is a transformative model that reflects the evolution of our thinking post COVID. It takes into consideration learnings from the pandemic and the need to design an industrial system that is inherently more resilient to future shocks and stresses and truly integrates European Green Deal social and environmental principles.

To be effective, the ambition level for transition to Industry 5.0 would need to be aligned to the scale of challenges facing Europe and the world, and at the same time target

national and international policies, as well as critical subnational actors like cities, regional bodies and local communities where consumer behaviour and public sentiment catalyzes demand. Industry 5.0 represents an opportunity for Europe to reframe the quality of its leadership in the world through international cooperation, openness (while at the same time strengthening strategic autonomy in a way which is aligned with SDGs) and leadership in setting standards and norms for new manufacturing, sustainability, ethics and a digital economy/society. To give an example: less than 1% of textiles are currently collected and returned to the value chain post use in Europe, and the trends are worsening not improving. Setting an ambition level within an Industry 5.0 context at the sector level focused on regenerative, circular economy principles and material flows/use, aligned with the vision, would send a strong signal to the actors in the economy that policy is re-aligning to a new economic paradigm. Setting an EU target of say 50% of textiles materials flows returning to the value chain by 2030 would be appropriate and focus R&D on high potential high impact and scalable new technologies, encourage the alignment of value chain actors and the creation of captive demand, alignment of capital and scale infrastructure investment. However, this would need to be accompanied with a proper trade and development policy fostering cooperation, secondary market and circular economy infrastructure in third countries to ensure a fair and just transition.

Global leadership would be further reinforced by leveraging the institutions and precedents for global financial rule making used in the wake of the credit crisis. Europe could set up an 'Industry Stability Board' analogous to the Financial Stability Board, recognizing the scale of systemic, strategic risks facing businesses and industries in Europe and globally from multiple connected shocks and stresses as well transition costs.

This would imply identifying industry and businesses globally and locally that are deemed 'too systemically important to fail' whereby failure = failure to transform in a fair and just manner while meeting the objectives of the Green Deal. These businesses would be required to demonstrate evidence of change to meet a set of de-carbonization requirements, resiliency measures, circular economy principles, regenerative practices and stakeholder requirements (people-planet-sustainable prosperity) in order to continue to have access to credit, regulatory approvals and licenses to operate. Europe should also use FTA negotiations to collaborate with partners on ways to ratchet sustainability standards for industry, internalizing eco-design standards or its forthcoming product policy and ensuring decent work and social criteria.

(Source: Industry 5.0 a transformative vision for Europe – European Commission)

4.1 New values and leadership for a sustainable and innovative industry

We therefore need new organizational and managerial models - focused on the valorization and involvement of workers - that cannot ignore a process of requalification of internal skills.
This process must be aimed both at the technical skills needed in an increasingly automated context - operators must be able to use these technologies and interact with them, understand their risks and potential - but, above all, the more "soft" skills that are essential to create a business model that truly involves and valorizes the entire workforce and that generates value through innovation.
(Source: CDC Global Supply Chain Report 2021 - Boston Consulting Group)

4.2 Why is it important to measure?

Then there is a second theme, also essential to promote change in companies in a sustainable perspective: measurement. In order to improve any aspect of the business, it is necessary to know it, monitor it, verify whether the efforts introduced are actually leading to the objectives set. This involves first of all having visibility on the impact of internal processes but, above all, being able to measure what happens along the supply chain.
(Source: CDC Global Supply Chain Report 2021 - Boston Consulting Group)

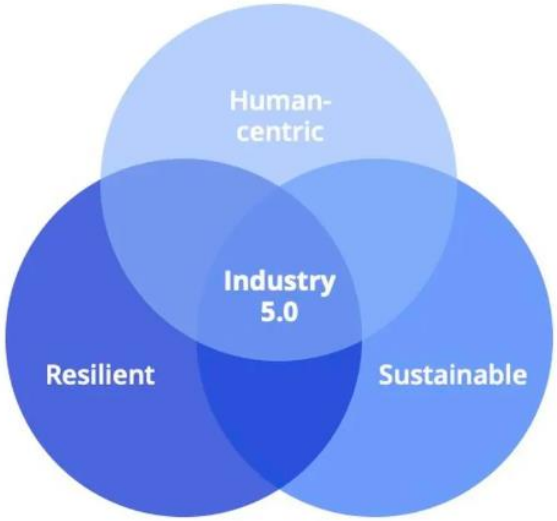
4.3 The role of supply chains and the innovation ecosystem

Supply chains are in fact responsible for over 90% of CO2 emissions produced by a company. Yet, according to a recent survey, only 10% of companies measure overall emissions (therefore internal and along the supply chain).
Similarly, a company could implement social sustainability strategies internally – through inclusion policies, company benefits, flexible work or even sustainability projects in collaboration with local entities – and not know that it is relying on a supplier that violates workers' rights or conducts its activities in a way that is harmful to the environment. This last consideration brings us back to one of the most important aspects of Industry 5.0: sustainability at the ecosystem level. Consider how, for example, Industry 4.0 has already led to an evolution of the relationships between the actors in the innovation ecosystem and has favored the transition from models based on competition to models focused on collaboration. The scale of the challenges that companies are facing, the diversity of their needs and technologies adopted, as well as the speed at which technological progress moves have pushed suppliers of technologies for digitalization and industrial automation to understand that no company can do it alone.
We have thus moved to an open innovation approach, based on standards that allow companies to choose the right supplier for a product, without worrying about integration with existing technologies. This allows end users to adopt, even through revamping and retrofitting, solutions capable of promoting efficiency and sustainability within the company. For suppliers, on the other hand, it means creating an ecosystem capable of creating value both for the companies that participate in it and for their customers and seizing new business opportunities, thanks to services based on the circular economy.
(Source: CDC Global Supply Chain Report 2021 - Boston Consulting Group)

5. The three pillars of Industry 5.0, from the centrality of man to resilience

The transition from Industry 4.0 to 5.0 promises to be very significant, especially from a conceptual point of view. While historically, industrial evolution has always been directed towards process efficiency, with a particular focus on automation, 5.0 embraces a different vision, in which the human factor and technology work together to achieve common goals. From a technological point of view, the model continues what 4.0 did and

inherits its winning solutions in terms of innovation and efficiency, but shifts the focus from technology and its cyber-physical systems to humans.



The Three Pillars of Industry 5.0 BASED ON THE EU PUBLICATION "INDUSTRY 5.0 HUMAN-CENTRIC, SUSTAINABLE AND RESILIENT"

5.1 Human-Centricity

In a human-centric vision, one of the founding values of Industry 5.0 can only be the well-being of the worker. The goal of human-machine interaction, which pervades the entire paradigm, is to create a safe, ergonomic and stimulating working environment that enhances human capabilities and reduces the risk of accidents. Advanced human-machine interfaces (HMIs) and collaborative robotics (cobots) allow repetitive and hazardous tasks to be automated, leaving more creative and strategic tasks to operators. (Source: CDC Global Supply Chain Report 2021 - Boston Consulting Group)

5.1.1 Human-Centricity and workers

The human-centred approach of Industry 5.0 is changing the way workers are viewed. They are indispensable resources, essential for driving innovation, productivity and the well-being of a company, and not simply a cost to be reduced. Industry 5.0 moves away from workers as economic output: it places more value on people, beyond a purely economic view. It recognizes the fact that workers are not just passive participants in production processes, but active contributors, whose involvement and empowerment are

essential to the achievement of company goals. Encouraging greater equality and empowering workers not only complements the growth of a company but stimulates growth itself. They are not just an accessory to growth, but a fundamental incentive that drives it forward.

In an environment of rapid technological advances and changing market dynamics, companies need to equip their workers with the skills and knowledge they need to cope and thrive through change. This means investing in upskilling initiatives that enable employees to acquire new skills, adapt to emerging technologies and seize opportunities for growth and development. Focused mainly on rapid automation, Industry 4.0 has, in some cases, generated mistrust and insecurity among employees regarding their ability to adapt to new technologies and their future employment in the company. This approach is in line with industrial Europe's position on a just transition, which considers workers as actors of their own destiny.

The human-centered approach of Industry 5.0 highlights the importance of anticipating and adapting to change. Industry 5.0 recognizes workers as a valuable resource rather than a cost. By recognizing and encouraging the intrinsic value of workers, companies can create a sustainable and prosperous work environment where workers feel valued, motivated and empowered to contribute meaningfully to the success of their companies. Industry 5.0 aims to combine the efficiency of digital technologies with the creativity, skills and abilities of workers. It aims to adapt digital technologies to the needs of workers in the industry and to create a safe and inclusive workplace where workers feel empowered and responsible. By supporting great interaction between man and machine and placing workers at the centre of digital transformation, Industry 5.0 aims to make the most of human capabilities.

Industry 5.0 places workers at the centre of operations and values them as key contributors to the entire organizational ecosystem, unlike traditional models that often value workers only in financial terms. In this paradigm, workers are seen as fundamental resources and not as a burden. Their diverse knowledge, skills and experience drive innovation and continuous progress in the company. By actively involving workers in decision-making processes and granting them autonomy in their role, companies can unlock their full potential.

Industry 5.0, which focuses on people and puts work at the centre of production processes, can play a crucial role in successfully completing the double transition. By strengthening the role and impact of industry on society, Industry 5.0 is truly capable of combining the social (human-centred) dimension with the double transition. By promoting worker empowerment and participation in decision-making processes, Industry 5.0 will also strengthen collective bargaining in the workplace. Collective bargaining also aims at ensuring a fair digital and ecological double transition and a more

just society. It is clear that the transition is more advanced and to the benefit of all in countries where collective bargaining structures are robust and fully operational at all levels, in particular at sectoral level4 and where social partners have room for negotiation. An example of the inclusion of the human principle is the framework agreement on digitisation5 concluded by the social partners in 2020. This agreement allows employers and trade unions to jointly address the digital transformation.
(Source: Position paper 2024/152-Industry 5.0: why should workers be interested? - IndustriAll European Trade Union)

5.1.2 A new role for workers

Industry 5.0 introduces a significant change in the role of the worker and the related narrative. The worker should not be considered as a "cost" but as an "investment" that enables the development of both the company and the worker. The employer is therefore interested in investing in the skills, capabilities and well-being of employees in order to achieve its goals. This approach is very different from simply balancing labor costs with financial revenues: it implies greater valorization and appreciation of human capital. An important prerequisite of Industry 5.0 is that technology serves people, rather than the other way around. In the industrial context, this means that the technology used in production is adapted to the needs and diversity of workers, and not that the worker must continually adapt to the constant evolution of technology.
There is greater worker empowerment, and the work environment is more inclusive. To achieve this, workers must be deeply involved in the design and implementation of new industrial technologies, including robotics and AI. Human-machine collaboration has been the subject of several Horizon 2020 funded projects (see Annex I).
The Factory2Fit project, for example, aims to empower and engage workers in a more connected industrial environment. Workers are given more weight and therefore more responsibility in shaping the production process, through virtual means. The project led to the construction of a virtual factory in which ideas can be tested and developed in co-design sessions with workers and other members of the working community. A dashboard for workers' feedback was created, allowing them to provide personal feedback on their achievements and well-being. The first results of the project indicate a positive impact on both productivity and worker well-being. Initiatives of this kind allow to connect the ever-increasing automation with the human experience, thus reinforcing the anthropocentrism of the approach. Another example is that of Romero, Stahre et al. (2016), who identified different typologies for Operator 4.0, focused on expanding the capabilities of the industrial worker with innovative technological means, rather than replacing the worker with robots.

This is the projection of 8 future types of operators: Super-strength Operator (operator + exoskeleton), Augmented Operator (operator + augmented reality), Virtual Operator (operator + virtual reality), Healthy Operator (operator + wearable tracker), Smarter Operator (operator + intelligent personal assistant), Collaborative Operator (operator + collaborative robot), Social Operator (operator + social network) and Analytical Operator (operator + Big Data analysis).

In this approach, man remains at the center of the production process and technology maximizes the advantages for both the company and the worker.

(Source: Industry 5.0. Towards a sustainable, human-centered and resilient European industry, 2021 – Commissione Europea)

5.2 Environmental sustainability

The new industrial era aims to address the most pressing global challenges, going beyond simple production optimization. It is therefore not surprising that there is an emphasis on environmental sustainability, which must be sought in eco-sustainable production practices, using renewable energy and minimizing waste. Industry 5.0 also promotes circular and low environmental impact production models, supported by the use of advanced technologies such as artificial intelligence and the Internet of Things (IoT).

5.2.1 What we mean by sustainability

The definition on which modern sustainability policies are based is the one provided by the World Commission on Environment and Development in a report published in 1987. In the document, sustainable development is defined as "a model of development capable of ensuring the satisfaction of the needs of the present generation without compromising the ability of future generations to realize their own". From this definition, it is clear that sustainability has not only an environmental dimension, but also a social one, as it requires that human activities be expressed in the responsible use of resources and in respect of the planet, so as not to harm the rights of future generations.
At the same time, sustainability has an economic dimension, as the generation of profit promotes well-being within society. Any model that is truly sustainable must be able to "resist over time" in full respect of the environment, human rights and continuously ensuring the creation of value (and therefore well-being) for society as a whole.
(Source: Brundtland Report - World Commission on Environment and Development)

5.3 Resilience

The European Commission argues that the Industry 5.0 paradigm should be directed towards the transition to 'a sustainable, human-centred and resilient European industry'. It is therefore the EU itself that points to resilience as one of the conceptual pillars of Industry 5.0, an obvious consequence of the lessons learned in the Covid era. The resilience of the industrial ecosystem is the result of the combination of operational flexibility, advanced digitalization, decentralisation and the ability to adapt to external and internal circumstances.

5.3.1 Why sustainability is (also) a question of resilience

The third pillar of Industry 5.0 is resilience. A topic that has always been important to industry but which has been given increased attention as a result of the supply chain disruptions that have occurred in recent years.
The previously mentioned European Commission document places great emphasis on the actions that need to be implemented at the supply chain level in order to meet this challenge. In particular, it focuses on these principles:

- an in-depth understanding of de-risking through resilience building
- adopting an approach that takes into account people, planet and prosperity. This approach focuses on short-term action and long-term planning, rather than the pursuit of immediate profit
- identify supply chain fragilities to work on industry self-sufficiency to reduce fragilities Decentralized supply chains to identify gaps between where production takes place and where there is a need for that product. A theme that relates, in particular, to the fight against world hunger and food waste, but not only
- keeping in mind, in digitalization projects, the risks to be balanced and the factors to be mitigated so that digital technologies do not exacerbate existing inequalities or criticalities

Industry 5.0 will help achieve the daunting challenge of moving to a circular economic model, i.e. a production and consumption model that is based on sharing, renting, reusing, repairing, refurbishing and recycling existing materials and products in order to extend their life cycle and minimize waste generation.
On a technological level, Industry 5.0 builds on the achievements of Industry 4.0.
While some elements of Industry 4.0 had represented a real break with the past - such as IT/OT convergence, the elimination of company silos, communication between machines from different vendors, etc. -, the technologies of Industry 5.0 build on the achievements of Industry 4.0. -, Industry 5.0 technologies are, or at least should be, already present in the company. It is therefore a question of how they can help companies realize their responsibility towards the environment and people, while continuing to promote efficiency and competitiveness (necessary for profit generation).

6. Industry 5.0 Technologies

Technology is obviously the enabler par excellence of the Industry 5.0 paradigm, just like for smart manufacturing. According to the European Commission's 2021 Policy Brief Industry 5.0 - Towards a sustainable, human-centred and resilient European industry, the new model shifts the emphasis from individual technologies to a more systemic approach, based on six categories designed to operate in synergy:

- Individualized human-machine interaction;
- Bio-inspired technologies and smart materials;
- Digital twins and simulation;
- Data transmission, storage and analysis technologies;
- Artificial intelligence;
- Technologies for energy efficiency, renewable energy, storage and autonomy.

6.1 Smart Industries: why become 5.0?

Even if the 4.0 paradigm has not yet fully expressed its potential, the time has come to think in terms of 5.0. This is because, as we have seen, 5.0 is not simply based on a more advanced technological platform, but is above all an evolution in cultural and conceptual terms: it is therefore possible for a smart company to immediately direct its efforts towards the new model by investing above all in a change of mindset and focusing its efforts towards a more sustainable, human-centric, solid and collaborative industry.
In support of the investment, we can identify (at least) five valid reasons.
To set the course for systemic transformation, corporations need to change their mindset, and orient their action towards Industry 5.0 objectives. The consequences of such a transition are profound, and directly challenge the incentive scheme followed by most corporations today, focused on short term gains, as well as on shareholder primacy. The need to depart from the shareholder model of capitalism has been evoked even by past champions of this approach such as the American Business Roundtable, and was echoed by the World Economic Forum and by U.S: President Joe Biden among others. At the same time, moving towards "stakeholder capitalism" is also unlikely to lead to an adequate consideration of the need for deep, systemic transformation.
As a result of the existing mismatch between corporate incentives and needed objectives, business leaders wishing to place their corporations on a transformative path are often criticized, when not ousted by their boards. This is why a new European Enterprise Model is needed, in which corporate progress and performance are measured coherently

with the role businesses are expected to play in this ambitious, transformative plan. The current work of the European Commission on proposing a new framework for sustainable corporate governance appears to be timely and necessary, but its current legislative trajectory appears to be facing significant challenges. While an in-depth analysis of the current proposal would fall beyond the scope of this paper, it is important to highlight the importance of requiring that companies' board integrate sustainability aspects into the business strategy, and set measurable, specific, time-bound and science-based sustainability targets to measure progress along those objectives.

Alongside legal reform, strengthening the framework for corporate social responsibility will contribute to the implementation of the objectives of industrial policy. By Introducing legal frameworks, minimum standards and certification/labelling, non-financial reporting on sustainability, mandatory due diligence and business model or strategic innovation in order to make CSR an effective tool to ensure that companies do not only act in a maximizing profit way but take proper account of social/ environmental/general interest concerns as part of their 'license to operate'. It should be the ambition of the European Pillar of Social Rights to guarantee that all workers have access to standard labour contracts with fair working conditions and to support all workers in their transition to the jobs and skills of a low-carbon economy.

(Source: Industry 5.0 a transformative vision for Europe – European Commission)

6.2 A necessary focus: AI and ethics in technology development

The ever-increasing adoption of AI within Industry 5.0 brings new challenges and significant ethical issues, including: ensuring data privacy protection, combating biases inherent in algorithmic systems and adapting employment policies to new needs. Furthermore, the extensive use of large databases raises concerns about information security, the risk of data abuse and liability for decisions made by the technologies themselves.

Therefore, it becomes crucial to find a balance between technological development and the well-being of society, through the adoption of stringent regulations and the encouragement of AI development practices that are safe, clear, transparent and ethical. On this topic, many scholars and experts in the sector are discussing and proposing more or less interesting food for thought to try to understand and govern the future developments that Artificial Intelligence brings with it.

The benefits of this technology are clear, but we must recognize that it also brings with it some risks, due in part to the technology itself and in part to the fact that it causes a very rapid transformation of our lives.

To identify them, we must first decide what role we want technology to have in our society. In my opinion, the role of AI is to support and accelerate the intellectual, cultural and social growth and awareness of people, together with the protection and support of human values. This is fully shared by the company where I work, which already in 2017 defined among its fundamental principles that "AI must amplify human intelligence, not replace it". Therefore, we need to understand what it means to amplify human intelligence, in order to then understand if some uses of AI can put this principle at risk. For AI and for technology in general, many important human values could run the risk of being negatively impacted.

For example:

- Privacy: among the most important risks is the management of data, which often also includes personal data, by AI systems. Privacy issues are therefore central. This is particularly acute with AI, given that machine learning techniques need large amounts of data. In Europe, the "General Data Protection Regulation" law tries to mitigate this risk.
- Fairness and Inclusion: the issue of fairness and inclusion is also important: if balanced data is not used, AI, trained on that data, could make decisions that discriminate between various groups of people. Furthermore, its use and possible excessive digitalization could exclude some categories.
- Freedom and control over decisions: machine learning techniques are not very "explainable" (it is often not clear how the machine arrives at its decision, starting from the input data) and this impacts both the human control of their decisions and the trust between people and AI, thus compromising their fruitful collaboration and its support for the improvement of human skills.
- Impact on personal growth and human innovation: the ability of AI to generate content (such as text and images) also introduces risks related to the impact on the education system, on creative works, on the conscious learning of logical reasoning mechanisms. If students use systems like ChatGTP to write an essay, will they be able to learn to create new ideas and therefore contribute to future innovations?
- Truth and information: ChatGPT and similar systems sometimes generate untrue, dangerous or inappropriate content. Without careful control, sharing such content can create false beliefs and undermine a system of respect and collaboration based on the truth of information, both locally and globally.
- Security and wellbeing: AI must not endanger our physical and psychological safety, and in general our wellbeing.

We cannot allow a technology, and its use, to damage fundamental human values. This is true for any technology, but AI has two additional factors to consider. First, AI at this point seems to be approaching a quasi-human behaviour, at least in the mastery of language. Second, the term used for this technology, Artificial Intelligence, scares us because of the fear of being replaced by other entities, perceived as intelligent as or more than us. These factors contribute to putting at risk our very sense of human identity.

Thus, technological development and innovation strategies are mixed with ethical questions about the impact of AI and many actors in society find themselves talking about ethics much more than they did in the past with regard to other technologies.
"The ethics of AI is concerned with identifying the ethical problems of the pervasive use of AI in our society and providing possible solutions, both technical and non-technical, to these problems. It is a multi-disciplinary and multi-stakeholder field of work, where experts from various disciplines (such as AI, economics, sociology, philosophy, psychology) and various actors in society (such as companies, universities, politicians, citizens' and consumers' associations) work together to generate solutions that include principles, guidelines, technological tools, governance systems, international standards, risk analysis systems, and laws, in a mosaic of complementary actions that address problems from various angles in order to generate global solutions."
(Source: Ethical AI is Everyone's Responsibility: The Foundations for Achieving It. Francesca Rossi - IBM AI Ethics Global Leader, IBM Research, T.J. Watson Research Center, New York, USA, 2023)

In recent years, there have been many subjects and moments of reflection on the topic. Many have published or are working on scientific articles, principles, requirements, rules, certificates or standards and laws, with the intent of studying and addressing some of the aspects listed above and related to AI ethics.
Some examples are:

- The United Nations: The annual "AI for Good" conference, organized by a UN agency, aims to understand how to use AI to get closer to the UN Sustainable Development Goals, by bringing together AI experts with hands-on experience of the issues to be addressed;
- The World Economic Forum, with its AI working groups involving experts from around the world representing businesses, governments and academia;
- The European Commission, with its multi-disciplinary AI working group and its AI bill, currently under discussion in both Europe and America;
- The US government, with the "AI Bill of Rights," which outlines human rights that should not be harmed by AI or other technologies;

- Scientific conferences such as AIES (AI, Ethics and Society) that present technological and socio-technological innovations to an audience of experts from various disciplines;
- Organizations such as the OECD (Organization for Economic Cooperation and Development), with its principles on AI;

- The Vatican, with the "Rome Call for AI Ethics", published in 2020 and signed by companies such as IBM and Microsoft, and recently (2023) also by representatives of the three Abrahamic religions.

All these attempts highlight how the theme of the development of artificial intelligence has a fundamental importance both for economic and business development, and from a social and human development point of view.
The theme remains open and it will be necessary to follow with interest these and other moments of reflection and discussion in order to know and govern this powerful tool for innovation. This excerpt from an interview with Father Benanti, member of the United Nations Committee on Artificial Intelligence for The Adecco Group, experts in HR consulting and solutions, can suggest some reflections:
"Artificial intelligence is a field in strong expansion today, but in what sense can we speak of "intelligence" in this case? And is there a dimension of human thought that cannot be assimilated to algorithmic computation? Today, many solutions are sold that help us, such as digital assistants in smartphones or at home, but this practical diffusion of artificial intelligence still does not answer this question. Furthermore, it is currently very easy to attribute to the machine a high cognitive capacity, the one that a child acquires around the age of 14-15. To be able to calculate the cube root of nine, at school, we had to wait a few years, a calculator does it immediately. On the contrary, a child at one and a half or two years old is able to open the door of the house with the handle and run away, while a robotic hand is not yet capable – with the current state of technology – of using a handle. This paradoxical situation tells us that perhaps we had a problem in identifying the central nervous system understood as the brain with the seat of intelligence, because what we see in the human being is that intelligence is also distributed within the entire motor process. And this is why it is not possible to immediately translate that great intellectual capacity that allows us to incorporate very complex mathematical functions into a chip, into the movement capacity of a robotic hand. We have conceptualized intelligence as if it were something abstract and resident in a central processing unit, while instead it is something corporeal: it is embodied, it belongs to our body. How can we define the relationship between an artificial intelligence machine and the realm of ends, of ethics? If we want to give the machine a certain degree of independence from a human

controller, the question arises of how to reconcile numerical values with ethical values. This is why I proposed writing this new great chapter of ethics, which is called "algoretics". But what should algoretics be? Certainly not an ethical awareness of the machine, because the machine is not someone, otherwise we would be faced with the same problem as above. We can understand it as a sort of ethical guardrail, which keeps the machine within a road and, as far as possible, avoids some unfortunate events. Then there is a whole other question, and it is a question of how to manage this threshold of ethical attention for the machine. It is clear that here we are talking about moving away from a model of professional ethics, according to which the engineer who is ethical is enough, and everything else follows in cascade. So it's not just about equipping the machine with the ability to judge, which is impossible, and not even just about replacing it with these ethical guardrails."
(Source: Interview by Ilsole24ore with Father Benanti - member of the United Nations Committee on Artificial Intelligence)

6.3 Efficiency

In terms of efficiency, the 5.0 paradigm continues the path traced by Industry 4.0 through the integration of technologies such as IoT, Artificial Intelligence, Digital Twin and Advanced Analytics. Thus, it is possible to optimize production processes, reduce production times and minimize waste, also promoting sustainability.
Empowerment and productivity: in addition to the well-being mentioned above, in Industry 5.0 people maintain control. This creates an environment in which operators have an active role in the decision-making process and can contribute significantly to innovation, with very positive effects on productivity parameters.
Competitiveness: Adopting a 5.0 paradigm allows companies to remain competitive in increasingly globalized and dynamic markets, which require operational flexibility, resilience and true mass customization. Not only that: the focus on sustainability, typical of Industry 5.0, also has a significant impact on brand reputation and company competitiveness.
Development of new skills: The adoption of technologies such as AI and collaborative robotics stimulates the development of highly specialized skills. This not only improves business efficiency but also promotes the professional growth of employees.
Attraction of talent: The skills gap is very much felt in the manufacturing sector. Companies that embrace Industry 5.0 become attractive to the best professionals, who enjoy working in innovative, stimulating and technologically advanced environments.

7. Industry 5.0 in European countries

However, all the principles that drive Industry 5.0 and the green and technological revolution need to be put into practice in order to bring the desired results.

This fundamental step requires actions by the various countries to govern and give impetus to this change, trying to identify the most effective actions for the various economic and social realities present in Europe. To ensure that industry becomes a pillar and driver of sustainability, regeneration of nature and inclusion rather than constituting a threat puts radically new demands on government, public policy and the interaction between industry and the state. First, it requires new policies and policy instruments, new partnerships, and new objectives for policies affecting industry. Second, it requires a portfolio approach to research and innovation projects, combined with the willingness and a mandate to take informed risks. Third, it requires agility, in the form of resource fluidity (i.e. the ability to quickly allocate and reallocate budget and other resources), and in the form of an improved ability to respond quickly to changing circumstances. Finally, it requires an ability to link policy processes, policy areas and governance levels in a more efficient and user-friendly manner, with users here defined as industry, citizens, and other stakeholders. Thus, in a nutshell, industry 5.0 needs government 5.0.

Public sector decision-making and processes are out of sync with the speed, uncertainty and transformation imperative. In many countries, there is a significant discrepancy in the pace of change (and sense of urgency?) between, on the one hand, companies, industries and individuals, many of whom are acutely exposed to far-reaching disruption and rapid change, and, on the other hand, large parts of the public sector that for various reasons moves at a much slower speed. Tackling the increasingly urgent and existential challenges we face, and seizing the opportunities that arise in times of disruption, critically depend on a better alignment between the public and private sector.

Achieving this result requires the following steps:

- Policy processes, including regulatory change, need to focus more on breaking path dependencies – in areas such as behaviour, regulations, incentive structures and policy design – that lock us into old patterns of consumption, production and organization. Policymaking needs greater awareness of how to achieve 'unlearning', address lock-ins and overcome inertia of patterns, policies and processes that prevent necessary and desirable change.
- Compliance processes need to happen in parallel rather than sequentially. Notably, there is a need for better governance of policy processes facing new, disruptive and system-changing actors and solutions. Currently, the achievement of systemic changes is hampered and discouraged by sequential policy processes (first you get a permit from one government agency, then you need approval from

the next government agency, etc.) which are out of sync with the pace of change required to tackle climate change and handle technological changes and competitive pressures. Furthermore, new actors and solutions often have to navigate a multitude of government agencies with different expertise and responsibilities, without anyone in government assuming a responsibility that the overall processes are effective, synergistic and time appropriate.

- Public funding for research and innovation in service of creating new, sustainable economic models, new markets and industrial ecosystems' needs to break out of its safety net of seeking sector-based, individual, business case driven projects assessed on the basis of discrete and recognisable deliverables in order to create the conditions to fund portfolios of actions that are more effective in facilitating unexpected, intersectoral combinations and transformative options for large scale structural change.
- Public funding for research and innovation in service of creating new, sustainable economic models, new markets and industrial ecosystems needs to break out of its current risk aversion.
- Public funding of all types grants, project finance, lending and investment – is conditioned to seek sector-based, individual, business-case-driven projects, assessed on the basis of discrete and recognisable deliverables, with the result that outcomes are more often than not siloed, substitutional and incremental. An overhaul of the structures and support mechanisms for public funding is needed in order to create the conditions to fund early and mid-stage portfolios of actions that are more effective in facilitating unexpected, intersectoral combinations and transformative options for large scale structural change.

(Source: industry 5 0 a transformative vision for Europe – European Commission)

7.1 A first feedback

As mentioned, the 5.0 transition is based on the 4.0 technological transition that has been underway for some years.

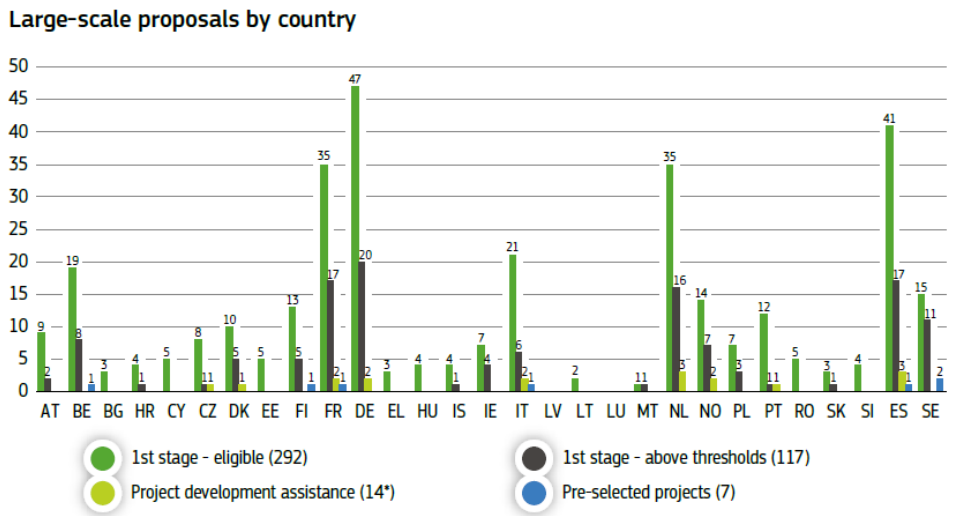
The situation in different countries regarding the capacity for innovation, the 4.0 transition and the ecological transition is evolving, but to date the situation between the different national economies is very different in Europe.

In 2023, the European Commission developed the "Innovation Fund Progress Report", which analyses the situation regarding the use of the Innovation Funds made available in

different countries and in different sectors, for different targets, already geared towards sustainability:

Energy intensive industries, including environmentally safe carbon capture and utilisation (CCU) that contributes substantially to climate change mitigation, as well as products that substitute carbon intensive ones; environmentally safe capture and geological storage of CO2 (CCS) projects; innovative renewable energy generation technologies; energy storage technologies.

The Innovation Fund aims to achieve geographical and sectoral balance in its lifetime until 2030. As illustrated below, the two calls concluded received applications from almost all Member States, projects are developed in many Member States, albeit with a lower representation in Eastern Europe. There are many cross-sectoral and cross-border projects with significant potential to decarbonise whole regions and sectors, beyond national and sectoral borders.



(Source: "Innovation Fund Progress Report 2022" –COMMISSION to the EUROPEAN PARLIAMENT and the COUNCIL)

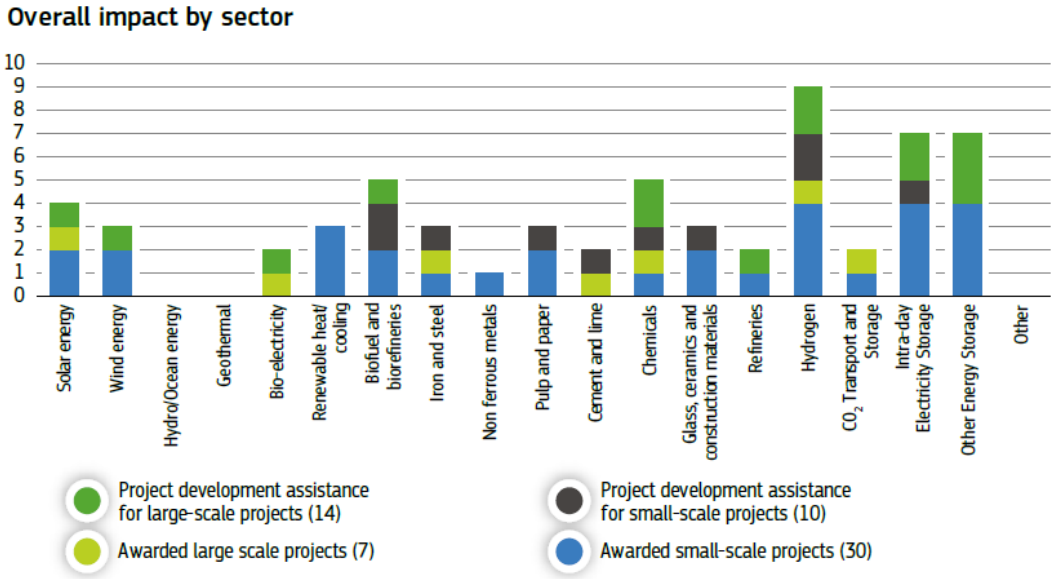
While implementing the Fund, the Commission will seek to further broaden the geographical balance through three specific avenues. First, the regular calls for small-scale projects with costs under EUR 7.5 million can be better suited to companies from smaller Member States which are looking to invest in clean tech at a smaller scale. Second, the project development assistance provided by the European Investment Bank to large and small projects can help companies prepare better applications and increase their chances to receive an Innovation Fund grant. Third, the Commission established a network of national contact points on the Innovation Fund in all EU Member States, Iceland and

Norway (19) that can provide information to potential applicants about the Fund and its interactions with national funding instruments and other EU programmes available in each Member State. Projects from nearly all sectors have been supported through the first two calls. The technological pathways of applying and awarded projects as outlined in Section 2.4.2. illustrate the variety of the project pipeline and shows that the Innovation Fund can serve all sectors currently eligible and potentially eligible in the future. For example, the Innovation Fund has already supported projects relevant to waterborne and road transports and until 2030 it can support the green transition of the whole EU economy, by funding clean tech solutions spanning from energy generation, to energy-intensive industries, transport, buildings and agriculture. The figure below illustrates the impact of the Innovation Fund per sector so far. The large differences between regions are a major risk, as some regions and their industrial bases are better prepared for the introduction of Industry 5.0 than others. We are already seeing an imbalance in the distribution of investments, as European Innovation Fund projects are being developed mainly in Belgium, Italy, Sweden, France, Spain and Finland.

It is therefore essential that the overall industrial strategy takes into account the regional dimension as well as the social and territorial cohesion of the European Union.

Industry 5.0 could be an opportunity to improve European resilience, security and strategic autonomy by implementing regional development plans. This approach not only fosters industrial innovation and competitiveness but also addresses regional challenges and contributes to a more sustainable and robust economic landscape.

(Source: Position paper 2024/152-Industry 5.0: why should workers be interested?, IndustriAll European Trade Union)



(Source: "Innovation Fund Progress Report 2022" –COMMISSION to the EUROPEAN PARLIAMENT and the COUNCIL)

These data can provide a starting point to try to say which are the countries that in recent years have invested more in innovation (and therefore in enabling technologies) those that can drive the 5.0 transition in the coming years. Innovation policy by definition targets more technologically advanced regions, those at the cutting edge of technological progress. Industry 5.0, because of its core principles of inclusivity and resiliency, implies strengthening innovation systems in regions in the periphery or those that are facing structural changes deserves special policy attention e.g. by taking into account the different levels of technological development when developing research and innovation programmes. The regional dimension deserves much more attention in the design of industrial policy. Industrial and technological progress has strong agglomeration effects and industry (especially in new emerging value chains) tend to concentrate in the more innovative, leading regions. Economic disparities across regions are persistent and deepening in Europe, leading to virtuous circles in the core regions and vicious circles in the periphery. Moreover, the climate transition will have a significant impact on carbon-dependent and less developed regions.

All this is leading to a growing number of 'left-behind' and 'de-industrialised' regions in the EU (not only regions formerly dependent on coal). To deal with the decline of regions, Industry 5.0 offers an opportunity to strengthen European resilience and security through regional redevelopment plans that localise transformation strategies and combine economic revitalisation programmes with social support and active labour market policies. Deliberate support and incentives for new business development and capability building to implement structural reforms at regional level would improve the quality of

institutions, modernise industrial infrastructure, upgrade the skill structure and enable the development of policies that allow moves to higher value added activities. These plans have to be supported by smart specialisation strategies, which are a regional and innovation-oriented form of industrial policy with a view to unlock latent comparative advantages of a region. Support must be provided in the form of capacity building to ensure the effective uptake of available funding mechanisms as well as to formulate a tailor-made approach for each region. Finally, the deployment of a circular economy with its decentralised value chains offers opportunities for creating local jobs.

It is necessary to help the regions that are currently most behind in terms of technological implementation through incentives of various kinds, otherwise they will never be able to access the opportunities opened up by the 5.0 transition.

This is also underlined by the European Commission in its work "Industry 5 0 a transformative vision for europe": Innovation policy by definition targets more technologically advanced regions, those at the cutting edge of technological progress. Industry 5.0, because of its core principles of inclusivity and resiliency, implies strengthening innovation systems in regions in the periphery or those that are facing structural changes deserves special policy attention e.g. by taking into account the different levels of technological development when developing research and innovation programmes.

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Deliberate support and incentives for new business development and capability building to implement structural reforms at regional level would improve the quality of institutions, modernise industrial infrastructure, upgrade the skill structure and enable the development of policies that allow moves to higher value added activities. These plans have to be supported by smart specialisation strategies, which are a regional and innovation-oriented form of industrial policy with a view to unlock latent comparative

advantages of a region. Support must be provided in the form of capacity building to ensure the effective uptake of available funding mechanisms as well as to formulate a tailor-made approach for each region. Finally, the deployment of a circular economy with its decentralised value chains offers opportunities for creating local jobs.
(Source: Industry 5.0 a transformative vision for Europe – European Commission)

7.2 Industrial policy for industry 5.0

The industrial policy of different countries is also called into question, finding today complex challenges for the implementation of the new paradigm 5.0, taking into strong consideration also the risks deriving from the new technologies implemented.
A fundamental aspect of industrial policy is its role in facilitating continuous adaptation within the economy. This involves supporting digital transformation, but also going beyond it and involving workers in innovation processes. Industrial policy must take into account the broader societal implications of technological change, including potential employment disruptions and social inequalities.
Industry 5.0 has profound and far-reaching implications for industrial policy and industrial workers. Industrial policy must provide a guiding framework not only to encourage innovation, but also to ensure a fair distribution of benefits, safeguard workers' well-being and mitigate negative consequences. Industry 5.0 must provide the framework for industrial policy to stimulate innovation, distribute benefits and ensure that no one is left behind. By adopting these principles, industrial policy can lay the foundations for a resilient and thriving industry that benefits both businesses and workers.
(Source: Position paper 2024/152-Industry 5.0: why should workers be interested?, IndustriAll European Trade Union)

7.3 Country focus

With the aim of analysing the level of digitisation of manufacturing and agricultural SMEs in Italy and in the main EU benchmark countries - Spain, France and Germany - TEHA Group developed a proprietary survey involving 400 small and medium-sized enterprises, half of which belong to the agricultural sector. The results of the survey probed the orientations and interventions in favour of digitisation of the manufacturing companies involved, with further detail on companies active in the agricultural supply chain, considering the significant impact that Intelligent Manufacturing can have for this sector.

A first data point denoting a gap between different EU countries concerns the presence or absence of Intelligent Manufacturing projects (already underway or planned) by the interviewed companies.

For example, while 18.3% of Italian SMEs have already integrated Intelligent Manufacturing technologies and 40.0% intend to do so in the near future, the percentage of SMEs that have not planned to adopt such technologies in their development plan is 41.7%. A number that is much higher than in other European competitor countries: in Spain only 16.2% of respondents did not plan to include Intelligent Manufacturing technologies, in France 32.3% and in Germany 13.8%. With reference to the causes that prevent companies in the 4 countries involved in the survey from investing in these new technologies, 37.6% declared a lack of usefulness in their business context as the main reason. In second place were economic and financial reasons (27.7%), followed in third position by uncertainty on the return on investment (26.7%). In the companies of the other benchmark countries, on the other hand, IT skills are ranked first by 53.8% of respondents in Spain, France and Germany, and those specific to the sector (34.7%) are considered substantially as important as engineering skills (32.8%). In line with Italy, however, is the indication on project management skills (in last place with 22.1%). Looking in detail precisely at the issue of skills, Italian companies report that those most relevant for implementing Intelligent Manufacturing are the specific skills of the sector in which each company operates (57.2%), followed by IT skills (44.9%). On the other hand, engineering skills (18.4%) and project management skills (16.3%) are considered less significant. Finally, looking at frontier issues related to the use of Artificial Intelligence in production contexts, in all countries companies indicate a willingness to envisage experimentations or uses of AI for their activities: in Italy 45.4%, in the other EU benchmark countries an average of 32.8%. This difference can be explained by the fact that Italian SMEs, on the other hand, lag slightly behind their European peers as far as already active experimentation is concerned: only 10.1% are already experimenting with AI solutions throughout the company and 15.4% in some teams, whereas in the other benchmark countries, 16.3% are already experimenting company-wide and 27.5% are already active in at least some teams.

(Source: Italia 5.0 - The skills of the future for the development of innovation in the age of artificial intelligence in Italy and the EU - The European House Ambrosetti, 2024)

7.3.1 ITALY

In the current context, characterized by continuous evolution and transformation, innovation emerges as a crucial element for the future of our country's competitiveness. Italy, like the rest of the world, is facing three fundamental challenges that will profoundly affect its economic and social development. These challenges are interconnected and must be tackled in a systemic way, involving all actors in society.
The first challenge concerns technology and productivity. Digitalization is a key factor for competitiveness and development. However, Italy still has a lot of work to do in terms of digitization and stagnating productivity. Italy's growth is lower than that of its global and European competitors, so it is crucial to accelerate the digitization process in order to improve productivity and position ourselves better on the international scene.
Secondly, Italy is facing a demographic crisis. For more than a decade, the Italian population has been in decline, and this phenomenon has significant implications for the labor market, the pension system and the social fabric of the country. Addressing this challenge is crucial to ensure sustainable growth and long-term economic stability.
The third challenge is environmental sustainability. The transition to sustainable practices is not only a global goal, but also a necessity for our country's competitiveness. European policies impose an acceleration towards sustainability and emission reduction. Italy must align with these goals and take effective measures to reduce its environmental impact, while ensuring that these policies do not compromise economic growth.
Against the backdrop of these three challenges, Italy also has a fragmented economic fabric. The Italian landscape is characterized by a high concentration of small and medium-sized enterprises, which constitute the essence of the national economy. It is key to initiate and accelerate the process of technological and sustainable transition starting with these enterprises, as they represent the exoskeleton of the Italian economic system. Italy's ability to address and overcome these challenges will be decisive for its future growth and sustainability. Responding to these challenges requires coordinated action and a collective commitment from all the actors involved, in order to build a more competitive and resilient future for our country. This chapter will delve into the three challenges facing the country, analysing the current situation and the main criticalities associated with each of them.
(Source: Italia 5.0 - The skills of the future for the development of innovation in the age of artificial intelligence in Italy and the EU - The European House Ambrosetti, 2024)

The Fifth Industrial Revolution, now underway, aims to put the human being back at the center of industrial production contexts, through a redefinition of the man-machine relationship, in which collaborative robots and Artificial Intelligence (AI) will be able to

support human work, increasing the capabilities and productivity of factory operators. To ensure that Industry 5.0 and the related digital transition represent a real development opportunity for Italian production companies, it is necessary to deal with the complexity of the current historical moment, identifying possible paths to give the right direction to these latest technological challenges, which will certainly affect 'Italian know-how', with important effects on the country system. In this regard, the Artificial Intelligence Observatory of the Polytechnic University of Milan recently reported that:

- "as many as 77% of Italians look at AI with fear";
- "already today, in Italy, AI has the potential to automate 50% of equivalent jobs […] to date only partially achieved, also considering that the role of AI is more of a support than a true replacement";
- "from now to 10 years, the new capabilities of machines could do the work of 3.8 million people in Italy".

The phenomenon of the introduction of AI applications in the world of work, to date, only marginally concerns Italian SMEs, considering that the AI market, in Italy, is 90% aimed at large companies. The next few years will therefore be decisive for conveying, even within SMEs, in the context of the Industry 5.0 phenomenon, the new technological applications equipped with AI, with the challenging goal of guaranteeing, at the same time, high product quality, typical of Made in Italy, and adequate employment levels. SMEs represent "4.78% of the Italian business fabric", but "they are responsible, alone, for 41% of the entire turnover generated in Italy, 33% of all private sector employees", therefore they remain a decisive factor for the socioeconomic development of the country. Professor Marco Taisch – lecturer at the School of Management of the Milan Polytechnic, as well as President of MADE Competence Center Industry 4.0 – recently underlined that Italy boasts the first manufacturing region in Europe, Lombardy, thanks to the quantity and quality of its production and an entrepreneurial culture nourished by a complex 'ecosystem', made up of public administrations, customers, suppliers, trade associations, research centers and universities, territorial innovation hubs, professionals. It is therefore clear how the current challenges related to the digital transition and Industry 5.0 fall on the entrepreneurial, socioeconomic and cultural structures of the Italian system, with such pervasiveness that it requires political decision-makers, universities and industry to work together to safeguard the wealth and values inherent in Made in Italy. In this context, the challenge for managers and technicians will be to identify, in production realities, a point of balance between new technologies and human beings.

(Source: L'Industria 5.0 per la Manifattura italiana – FabbricaFuturo, 2024)

In Italy, to give greater impetus to the 5.0 transition, the government has implemented several measures aimed at supporting companies in investing in 5.0 enabling technologies. The Transition Plan 5.0, in complementarity with the Transition Plan 4.0, is part of the broader strategy aimed at supporting the digital and energy transformation process of companies and makes 12.7 billion euros available to them in the two-year period 2024-2025. In particular, in line with the short and medium-term actions envisaged by the REPowerEU plan, Transition 5.0, with a total financial allocation of 6.3 billion euros, aims to promote the transformation of companies' production processes, responding to the challenges posed by the twin transitions, digital and energy.

"Transition 5.0 will be a tool for a new industrial policy that combines innovation and training: it is the first plan in Europe with incentives for the two transitions, green and digital, together with worker training," says Minister Adolfo Urso. "The measure will give a significant boost to investments by Italian companies, making them more competitive in the new global scenarios." That Industry 5.0 is an important change can be understood, but why could it be so important in Italy? How does Industry 5.0 fit with the typical characteristics of Italian manufacturing?

- Human Centricity: Italy, with its long tradition of manufacturing and craftsmanship, has always valued the human contribution in production. Industry 5.0 amplifies this tradition, putting humans at the center of the production process and creating safer and more stimulating work environments. While Industry 4.0 focused mainly on automation and efficiency, Industry 5.0 aims to re-establish the importance of human interaction in the production process. The goal is to create a synergy between humans and machines, in which human creativity and intelligence are enhanced.
- Sustainability: Industry 5.0 emphasizes the need for sustainable production processes. This includes the efficient use of resources, the reduction of carbon emissions and the promotion of green practices. With these premises, Italy can position itself as a leader in sustainable production. Not only will it help the environment, but also the economy, creating new opportunities for work and innovation.
- Global Competitiveness: Advanced technologies enable highly customized production on a large scale. This means that products can be adapted to the specific needs of customers without sacrificing the efficiency of mass production. Italian companies will be able to be more competitive globally. Products adapted to the specific needs of customers without sacrificing the efficiency of mass production. The ability to offer customized and sustainable products will increase the attractiveness of Made in Italy products.

Here the technologies that will drive this evolution:

- Artificial Intelligence (AI): To optimize processes, improve predictive maintenance and customize production
- Collaborative Robots (Cobots): That work side by side with workers, improving safety and efficiency.
- Internet of Things (IoT) and Big Data: To collect and analyze data in real time, improving resource management.
- Augmented Reality (AR) and Virtual Reality (VR): Useful for training, maintenance and design.

Industry 5.0 represents not only an economic opportunity, but also a way towards a more sustainable and human future.
Investments, therefore, in research and development, continuous training and incentives for the adoption of green technologies that are fundamental for the success of Industry 5.0 in Italy.
(Source: Industria 5.0 L'Italia ai Nastri di Partenza! Benvenuti nell'Era dell'Industria 5.0! – TDA Informatica, 2024)

However, to overcome all the challenges that Industry 5.0 brings to the Italian economy, the path is still long.
To date, in fact, it seems that the focus is mainly on environmental aspects, losing a bit of momentum compared to the real possibilities that the plan should bring. Anticipated for months, the Transition Plan 5.0 was approved by the Council of Ministers on February 26, 2024, an important date for companies that have suspended investments in view of its publication. The direction of the plan, however, does not seem to go in the promised direction, because the realization of Industry 5.0 still seems far away. And those who really know the issue - including Considi, the consultancy firm that was the first to talk about 5.0 in Italy - know that the implementing decrees of the plan (expected in the coming months) are intended to cover a part of the digital and ecological transition project, namely environmental sustainability. But it could not be otherwise, because most of the funds for Industry 5.0 (6.3 billion euros) come from the RepowerEu program, the mission of the National Recovery and Resilience Plan (PNRR), which aims precisely at energy sustainability. But just as experts on the subject know, Industry 5.0 certainly involves the use of technology focused on sustainability, but it focuses, above all, on the valorization of human beings within production environments. The new industrial model, in fact, is centred on people, because the processes must adapt to the needs of workers; furthermore, the new paradigm is resilient, because it strengthens solidity and flexibility to face periods of crisis, and it is also sustainable, because it aims to reduce the

environmental impact. These characteristics, therefore, find a partial reflection in the innovations of the 5.0 plan. "The 5.0 paradigm, as we studied it by the European Commission, has much broader contents and characteristics than the guidelines financed by the Italian plan. We know very well that Transition 5.0 is largely supported by sources from the PNRR, and in particular by RepowerEu, so we understand that it is not a lack of foresight on the part of the Government, but concerns the limits of the funds", comments Gianni Dal Pozzo, CEO of Considi.

The directives aim only at energy sustainability: based on this, it is clear that the link between Transition 5.0 and the PNRR results in a precise orientation of the financial instruments made available to companies. In fact, the incentives, proposed in the form of tax credits and for innovative investments of up to 50 million euros, are granted with a view to reducing at least 3% of total energy consumption and 5% of consumption of the production process involved. Furthermore, the tax credit varies depending on the energy bracket: for example, in the third energy efficiency class - the one that promises greater environmental sustainability results - it reaches up to 45% for investments of up to 2.5 million euros.

Companies that invest in efficient capital goods can request the incentive to invest in self-consumption of energy from renewable sources and in staff training. This is one of the points of the 5.0 plan in which the European Commission guidelines are most recognized: "It is obviously a shame not to have understood the directives more broadly, because the funds could have been used for other issues, starting with personal training, which is very limited in this plan", adds Dal Pozzo.

Beyond the greater orientation of the 5.0 plan towards environmental sustainability, there is a positive aspect in the Government's initiative, as the CEO of Considi explains: access to the contributions requires that the project be certified ex ante by an independent evaluator who confirms compliance with the admissibility criteria relating to the reduction of total energy consumption and, subsequently, ex post to confirm the actual implementation in compliance with the previous provisions. "This method protects companies with respect to the eligibility of the financing, so that the investment cannot be contested later", concludes Dal Pozzo. What is expected in 2024 and 2025 is therefore a further step forward towards Industry 5.0, but not yet a true 5.0 transition as it has been theorized. To truly put the person at the center we still have to wait.

(Source: Industria 5.0, la transizione a metà dell'Italia– FabbricaFuturo, 2024)

7.3.2 SPAIN

Spain stands out for a higher level of digitisation than many other European countries. This is reflected not only in the business sector, where Spain has a high Digital Intensity

Index, even among SMEs, but also in the digital skills of the population. In fact, according to the DESI index, 66% of Spanish adults have basic digital skills, a percentage that exceeds the European average.

Among the analysed countries, Spain ranks second in terms of funds received by the RRF, with a total of EUR 163 billion. In particular 21.74% was allocated to social expenditure, with more than half of this sum, 18.8 billion Euros, allocated to employment and skills. To this end, 33 measures were implemented, including 14 reforms and 19 investment plans.

One of the pillars of Spain's Recovery, Transformation and Resilience Plan is Digital Spain 2026, a roadmap for the country's digitisation process that includes 8 specific plans:

- The Digital Infrastructures and Connectivity Plan for society, economy and territories
- Strategy for the promotion of 5G Technology
- ENIA, National Artificial Intelligence Strategy
- National Plan for Digital Skills
- SME Digitalization Plan
- Public Administration Digitalization Plan
- Spain Audiovisual Hub of Europe
- National Cybersecurity Plan

In the context of the National Digital Skills Plan, Spain has invested between 2021 and 2023 a total of EUR 3.75 billion in digital skills training, of which EUR 997 million has been earmarked for upskilling for employment. In addition, the SME Digitisation Plan was launched to overcome the digital backwardness of Spanish SMEs, which represent 98.99% of all companies in the territory. This plan envisages a total investment of EUR 4,656 million over the period 2021-2025, divided into four main lines of action:

-Basic digitisation of SMEs
- Innovation and entrepreneurship
- Change management support
- Supporting sectoral digitisation

A major initiative within this plan is Activa Industria 4.0, a specialised and customised consultancy programme for Spanish industrial companies. Each participating company receives digital strategy recommendations from consulting firms and a contribution of EUR 7,400. In 2023, EUR 24.5 million has been allocated, giving more than 3,300 SMEs the opportunity to participate and benefit from the service. Another important programme is Acelera pyme, to which EUR 250 million has been allocated between 2021 and 2024. The initiative is designed to help SMEs and the self-employed integrate digital

technologies into their production processes and value chains. This programme includes an online platform providing analysis tools and content for digital transformation, a network of offices to support SMEs in integrating ICT into their processes, technical support and advisory services, seminars and workshops.
(Source: Italia 5.0 - The skills of the future for the development of innovation in the age of artificial intelligence in Italy and the EU - The European House Ambrosetti, 2024).

The necessary update of the long-term economic strategy for Spain, in line with this new paradigm, is what we have called Spain 5.0. The path towards this Spain 5.0 must be based above all on the digitalisation of industry and the development of smart infrastructures, two strategic areas not only because of their high added value, intensity in R&D&I and their strong export capacity, but because both are essential to achieve the triple objective of the European Commission of a more sustainable, resilient and people-centred economy:

- Digital industries. The consolidation of a digital industry will allow Spain to be more competitive in international markets; have greater flexibility, control and adaptation to changes in production processes by monitoring and exploiting data; improve worker safety through cooperative robots (cobots), and guarantee, through a solid and updated national industry, the supply of essential products in critical situations, such as the recent COVID-19 pandemic. In addition, this digitalisation of the industry will allow the weight of the secondary sector in the Spanish economy to increase – this reindustrialisation sought by the European Recovery Plan – with greater added value and, therefore, generating more qualified and better paid jobs. This digital industry is also characterized by hyperconnectivity and the exchange of information throughout the entire value chain, which will require the collaboration of all agents – industries, customers, workers and suppliers –, forming an ecosystem that encourages innovation, collaboration and the constant updating of human capital.
- Smart infrastructures. On the other hand, the development of smart infrastructures is an essential requirement to guarantee the efficiency and environmental sustainability of all economic sectors, especially industry, transport, construction, energy, the hotel sector and health. These new infrastructures range from smart buildings to mobility solutions, the electrification of the economy or domestic self-consumption, among others, which requires a change in the energy paradigm in which all agents, including households, become active subjects of the system that guarantee the stability of the network in a coordinated manner. The necessary digitalization of industry and

infrastructure within this new concept of Spain 5.0 will require, collaterally, the development of a series of facilitators or catalysts for this change:

- New business model. As we mentioned before, hyperconnectivity will require a new business model where agents, large companies and SMEs, seek new schemes for collaboration, sharing of information and risks and integration of different technologies to create solutions adapted to the industry, scalable, standardized and that generate a positive return for manufacturers, forming an innovative ecosystem.
- Training. The challenge of digitalization in industry, with technologies that change and evolve rapidly, requires constant updating of knowledge within companies, and especially among workers, either to optimise performance in their current positions (upskilling) or, more importantly, to train them for new positions (reskilling) that are constantly being created (and also destroyed). This continuous training of staff will provide companies with flexibility to easily readapt to any technological disruption, and is a fundamental element so that this transition, in addition to being efficient, is fair and does not leave anyone behind.
- Cybersecurity. Finally, the other side of digitalisation and hyperconnectivity is, without a doubt, the risks related to cybersecurity. Progress cannot be made in this transformation if companies do not protect themselves against cybercrime and industrial espionage and if the security of a country's critical infrastructure cannot be guaranteed against possible cyberattacks. This protection must also be provided throughout the supply chain to be effective, so it is essential to raise awareness not only among large companies, but also among SMEs, of the importance of cybersecurity.

This two-way flow of information requires almost immediate communication between machines, or between them and the cloud, to allow real-time operation. This can be achieved more easily thanks to the development of industrial 5G, which is the new communication standard that is up to a hundred times faster than current systems, and which does not depend on whether other devices are connected or not at the same time. The industrial use of 5G therefore generates new opportunities for the industry and enables the arrival of other solutions that could not otherwise be developed.

The integration of more interconnected technology in the industry allows for hybridisation between the physical and digital worlds (i.e. the OT and IT environments): any product or process can be simulated in the digital twin prior to its implementation in a precise and accurate manner, saving costs in the design phase and allowing problems to be anticipated in subsequent production.

The manufacturing industry of Spain 5.0 will have to face two major challenges: one sectoral and one geographical. By sectors, it will have to rely on those in which it has traditionally been strong and is already well positioned in order not to lose its competitive advantage, such as the food sector, machinery manufacturing or the automotive industry. It will also have to direct its efforts towards those other industries that, without having a very high weight, do have a potential driving effect on the rest of the industries, such as the aeronautical or naval sectors. At the same time, it will also have to specialize in all those sectors yet to be developed and that have emerged, or will emerge, as a result of the digital transformation. Among them, cybersecurity undoubtedly stands out, a field that, will have to be developed even more in the coming years and in which Spain can position itself as a European leader and, why not, also a world leader.

To achieve the objectives of Spain 5.0 in an increasingly urbanised world with fewer resources, we must transform the way we live and work.

The environmental policies underway, such as the integration of more renewable energy - including self-consumption - and electric mobility, which will require the deployment of a charging network within cities, represent a major challenge in terms of the operation of the electrical system, which will have to deal with the volatility of renewable production - dependent on natural phenomena such as the sun or wind - and an increase in demand to charge these new vehicles, increasing the difference between peak and valley consumption. Given the difficulty of sizing a maximum network with all these elements, it requires, on the one hand, cultural changes for its successful implementation (new charging habits or car-sharing, for example), but also infrastructures that apply new technologies to monitor, control and manage these enormous, interconnected networks in an efficient, automatic and decentralized way, in which all agents participate actively. This is what is known as smart infrastructures. These infrastructures will allow us to abandon the traditional and unidirectional structure of generation > transport > distribution > consumption and move to a new model where all agents are active elements of the network, taking or pouring energy into it depending on the needs of the entire system. For the development of these smart grids, maintaining security of supply and integrating more renewable energy into the system will be essential to the development of energy storage, whether in the form of hydroelectric pumping stations, in the form of heat (storage in molten salts, as in solar thermal plants), in the form of gas (hydrogen) or in batteries. In the latter case, the lithium-ion battery is the technology currently available with a sufficient degree of competitiveness for its application at residential, commercial, industrial or large-scale (utility-scale) levels. By autonomous communities, the industrial leadership of some of them is evident, as may be the case of Catalonia, the Valencian Community or the Basque Country. These regions therefore have an adequate substrate for the development of innovation ecosystems around their specific industries

and that can be the germ of an industrial transformation that will filter through to the entire country through the capillarity of the economy.

As for those less industrialized regions, digitalization and European aid represent an opportunity to, on the one hand, take advantage of the connectivity and remote operation of the industrial operation and locate the talent and digital workforce in their communities and, on the other, specialize in the new sectors that have emerged in conjunction with the digital transformation of the industry and are yet to be developed.

Regarding the state of implementation of "Industry 4.0" in Spain, 21% of industrial companies can be considered digital novices (they are in an early phase of digitalisation), 47% digital followers (they have some functional areas digitalised and connected) and 27% digital innovators. Only 5% can be considered digital champions or digitally advanced (they have already fully digitalised and integrated their entire value chain: manufacturing and operations processes, human capital, commercial processes and their relationships with customers and suppliers), compared to 10% worldwide25. In other words, almost 2/3 of Spanish companies are falling behind in the digitalisation process.

Furthermore, 80% of the income of Spanish industrial companies continues to come from traditional products and services, compared to a mere 20% whose income comes from products and services with some digital component26. Therefore, in terms of digitalisation, there is still much to be done. By type of solution, the degree of technological implementation is very uneven. Spain is further behind other European countries in 3D printing (8% of Spanish industrial companies, compared to 12% of the EU average), the use of big data (7% compared to 11%) or cloud services (24% compared to 36%), but it shows more positive results in IoT (15% compared to 19%) and robotics (20% compared to 19%). One of the indicators that can help us understand the speed at which countries could evolve in the digital and ecological transition is the value of research and development expenditure. As regards R&D, in Spain a large part of the gas achieved by companies in this area is attributable to the industrial sector. More concretely, in 2019 the expenses in R&D of the industry accounted for 46.5% of the total. Considering its importance, the gas in R&D made by the Spanish industry is low in comparison with the gas dedicated in other countries around us. Measuring the industry's R&D spending as a percentage of GDP, Spain spends 0.8%, as much as France or Italy and four times less than Germany.

Finally, are proposed some barriers that can hinder the 5.0 transition: the current financial situation; the limited capacity of the corporate structure (dominated by employees) to participate in projects and activities; and the lack of financial returns in companies which causes cooperation with the university to have a very low priority for companies. The conclusion of the report with respect to this point is that to improve this

company-university cooperation in Spain, is necessary more research between research centers and companies that allow building personal relationships.

The mechanisms supporting collaboration are considered insufficiently developed in Spain. In this aspect it is where there is a greater discrepancy of perceptions among investigators and managers: the first consider that the strategies for the UBC, especially on this practical issue, are among the least developed in Europe, while managers evaluate it as the most developed in Europe. Continuing with the role that develops universities in the innovative ecosystem, also particularly relevant are the technologically based business incubators (spin-offs) that are generated within the scope of universities and business schools. Of the 215 incubators that are currently active in Spain, 23 are of university nature, which is why they represent around 10% of the total, making an essential contribution to the development of innovation and entrepreneurial entrepreneurship.

Through these incubators, Spanish universities can transfer to the market the results of investigations carried out by their departments and introduce their qualifications into the labor market. On the other hand, business schools implement these tools to boost the entrepreneurial vocation of their students and build a network of contacts with the entrepreneurial ecosystem. Considering the good understanding of these figures, Spain does not appear among the main countries in terms of incubators and accelerators of the UBI Global World Rankings of Business Incubators and Accelerators 2019-2020, and according to which the most outstanding university incubators are located in it countries such as Sweden, Canada, United Kingdom, Netherlands or Italy. On the other hand, other mechanisms of collaboration with the least developed universities in Spain are the leaders of alumni, the professionals of the world of business and industry in the areas of knowledge transfer or the presence of academics in the councils of administration of companies, among others.

(Source: Claves e inversiones estratégicas para una España 5.0 – PWC and SIEMENS)

7.3.3 GERMANY

As far as Germany is concerned, it seems that economic actors are reluctant to use the term 5.0, not seeing a clear line of implementation and innovation with respect to industry 4.0. However, Germany is ahead in terms of digitisation and skills. Germany ranks high among European countries for the number of ITS students, STEM graduates and ICT students, representing a model from which Italy can learn valuable lessons.

Of the four countries analysed, Germany receives the least amount of funds from the RRF, at only EUR 28 billion, a figure more than five times lower than that allocated to

Italy and Spain. Of these funds, 23.3 per cent went to social spending, with 36 per cent of this sum reserved for the development of employment, skills and education. To this end, 11 measures were launched, including 7 reforms and 4 investment plans.
The digital transition is another key area for Germany's economic development, receiving 52 per cent of the total RRF resources, mainly directed at developing digital skills and supporting the digitisation of enterprises.
The pillars of the recovery plan in the area of digital transition are:

- The Digital Educational Space - National Educational Platform: With an investment of 630 million Euros, this project aims to develop a (federated) network system with common rules, interfaces, standards and functions that enable every user to access and participate in educational offers by creating an integrated and highly accessible educational environment.
- The Programme for the Digitisation of the Economy: receives EUR 3.2 billion and includes several initiatives including the Investment Programme for Vehicle Manufacturers and the Supply Industry, the creation of Continuing Education Associations for SMEs, and the Centre for Digitalisation and Technological Research.

For SMEs, there are many digital development programmes such as the Mittelstand-Digital which offers guidance for craftsmen and SMEs willing to embrace digital transformation by informing them about the opportunities and challenges of digitisation, or the IT-Sicherheit which, through the transfer centre for cybersecurity, support SMEs in adopting cybersecurity technologies. Since 2015, for example, the Ministry of Economic Affairs has established a total of 26 Mittelstand 4.0 centres of excellence that provide SMEs with information and specific support on digitisation, through activities such as the assessment of digital efforts or the development of tailor-made digitisation roadmaps. There are also centres dedicated to Digital Crafts, eStandard, IT Industry, Communications and other sectoral clusters.
The National Skills Strategy complements basic vocational training: the Vocational Dual System, which combines theoretical education in vocational schools with practical training in companies. This approach is regulated by law, involves close cooperation between companies and schools and consists of:

- Standardisation of training: Recognition of around 330 professions and creation of a certification system to ensure that apprentices receive uniform training throughout the country
- Multi-stakeholder involvement: Role of the government, employers and trade unions in updating training regulations, ensuring that the system meets the needs of the labour market

- Digital innovation: The system is addressing the challenges posed by digitisation and new technologies, with specific initiatives to adapt occupations and training regulations.

Germany has put in place an ambitious strategy to develop advanced skills in artificial intelligence and support the integration of AI into the education system and the world of work. This strategy has two main fronts:

- Inbound training, supported through the expansion of learning platforms such as the AI Campus, offering courses, videos, podcasts and knowledge exchange to create a solid skills base in AI, the creation of at least 100 new chairs in the field of AI to strengthen the presence of this discipline in universities and the increased involvement of students in STEM subjects, thus preparing a new generation of AI experts.
- Lifelong learning will include the establishment of Centres of Excellence for Work Research, focusing on the study and organisation of work in an AI-based environment. Germany will also introduce the Skilled Labour Strategy, a skills monitoring system to identify the skills needed in the future.

Finally, regional Hubs of Tomorrow will be established to provide companies and workers with customised information and innovative learning approaches to shape change.

In 2018, Germany launched a National Strategy for AI with the aim of becoming a European leader. The strategy establishes essential framework conditions in the context of the dynamic development of technology and is conceived as a learning strategy that must be continuously readjusted by politics, science, business and civil society.
With the allocation of EUR 5 billion until 2025, Germany is committed to 12 fields of action including: private and public sector innovation, international collaboration, Industry 4.0 and support for SME transition.
(Source: Italia 5.0 - The skills of the future for the development of innovation in the age of artificial intelligence in Italy and the EU - The European House Ambrosetti, 2024)

The Research Council Industrie 4.0 and the Plattform Industrie 4.0 criticise the use of the term “Industry 5.0”. Industry 4.0 was presented to the general public for the first time at the Hannover Messe 2011 with an industrial model that is still highly topical and is spreading worldwide. The Research Council Industrie 4.0 and the Plattform Industrie 4.0 criticise the unfounded and unnecessary use of the term “Industry 5.0”, which contains no new content and contributes to uncertainty. Industrie 4.0 stands for the fourth industrial revolution and its ongoing transformation, which encompasses all areas of

society. The term "Industry 5.0" has been used more frequently recently to focus on "human-centricity", among other things. However, according to the Research Council Industrie 4.0 and the Plattform Industrie 4.0, the term Industrie 4.0 has always had the benefit for society as its most important goal. In addition, the term Industrie 4.0 stands for the fourth industrial revolution, which, like all previous revolutions, will take a long time to be fully realised. This includes people making use of new technologies and value creation models. The typical software abbreviation "4.0" symbolises the importance of software in this process but should not be understood merely as a version number and replaced by "5.0". It is now more than ten years since the term Industrie 4.0 was coined by Henning Kagermann, the former CEO of SAP, Wolfgang Wahlster, the former CEO of the German Research Center for Artificial Intelligence, and Wolf- Dieter Lukas, Head of Department and later State Secretary at the Federal Ministry of Education and Research. In the years since, the initiative that started in Germany has spread around the globe. Today, Industrie 4.0 is a term that represents a change potentially affecting all areas of society. It refers to the fourth industrial revolution. Like the previous three industrial revolutions, it can be assumed that the current one will bring about far-reaching changes and that it will take a similarly long period of time to fully play out. The typical software shorthand "4.0" refers both to the fourth industrial revolution but also emphasizes the special role that software plays in this process. It is a comprehensive concept that included, from the outset, technological aspects, new value creation models, the ability to create new types of products, sustainability, resilience and, in particular, approaches for optimally integrating and supporting humans involved in Industrie 4.0 solutions. As with every industrial revolution, the fourth industrial revolution also requires measures that build on one another. This means that a technical foundation and international standards must first be created, which then form the basis for the necessary skills and optimal support for workers in production. Active participation by employees is essential here. It would be completely wrong to view Industrie 4.0 through a purely technological lens. And it would be equally misguided to treat the abbreviation "4.0" simply as a version number and replace it with "5.0" on while still the same long but important and correct path.

In fact, this mistake has been more common for some time now: The term "Industry 5.0" has been put forth in the recent past. In addition to some AI-related content, the core of this term is often defined as "human-centricity", i.e., the goal to design labour processes in an optimal manner for workers alongside the best possible support for new production processes. While the content itself is valid, the new term "Industry 5.0" is not needed to describe it because "human-centricity" and societal benefits have been the most important goals of Industrie 4.0 from the outset.

The term "Industry 5.0" is neither necessary nor helpful. It does not contain any new content, and falsely suggests that the fourth industrial revolution is complete and that our attention can be turned to new topics. This unnecessary terminology could lead to uncertainty among companies and well-established international collaborations that are currently working on the implementation of the fourth industrial revolution. Plattform Industrie 4.0 and the Research Council Industrie 4.0 therefore strongly criticize the frivolous positioning of the unnecessary term "Industry 5.0".
(Source: The fourth industrial revolution and Industry 5.0, a critical perspective – National Academy of Science and Engineering)

However, there are large companies that are implementing technological solutions that also take into account the sustainability aspect and more generally the inspiring principles of Industry 5.0. Here is one of the many examples, implemented by SIEMENS for the development and implementation of a sustainable packaging machine thanks to the Digital Twin. "How can products be packaged in a more environmentally friendly way without sacrificing speed and flexibility? Swabian machine builder Hugo Beck has managed to do so with the aid of an inventive spirit, the right partners, and the digital twin. The result has been an innovative, resource-saving machine that packages products in paper in a batch size of 1. The clever machine that packages products according to their dimensions. Since 1955, Hugo Beck has been manufacturing horizontal film packaging, flowpack, and paper packaging machines. This family business located in the German town of Dettingen an der Ems is one of the world's leading specialists in high-quality packaging solutions. For example, the paper e-com fit machine automatically adapts the paper shipping bag to the product dimensions to save material and space, making it possible to package different products of varying sizes. This machine can be connected directly to ERP or MES systems and offers the option of remote monitoring and maintenance. It was developed in collaboration with customers and suppliers, and with Siemens as an automation and digitalization partner. Sustainable machines developed faster thanks to a holistic approach Hugo Beck's machines are as unique as its customers' requirements, but they all have one thing in common. Thanks to solutions from Siemens, Hugo Beck can adopt a holistic approach in order to implement innovative machine concepts faster. In this case, innovation means not only maximum performance, but also energy- and resource-efficiency for boosting sustainability. The Swabian machine builder has had such positive experiences with the Siemens portfolio that it will rely on it even more extensively in the future. Working with partners like Siemens, engineers developed and then quickly and successfully launched the paper e-com fit, a sustainable packaging machine for e-commerce and mail order that features recyclable paper instead of plastic and individually adapted packaging instead of standard dimensions.

(Source: Sustainable packaging machine thanks to the Digital Twin - Siemens Global)

7.3.4 FRANCE

Looking at France, it is possible to identify examples of effective e-skills development policies from which Italy could benefit to strengthen its position in the digital environment. First of all, France devotes 42% of the Recovery and Resilience Facility (RRF) social funds to actions aimed at supporting employment and skills enhancement, 26 percentage points more than Italy, which allocates only 16%. Furthermore, looking at the digitisation of the agricultural sector, France foresees specific initiatives for the digital skills training of the actors involved in the agri-food value chain, in contrast to Italy which, although investing in the digitisation of agriculture, focuses mainly on the upgrading of machinery and equipment, neglecting the development of digital skills of the stakeholders involved. In total, French resources amount to EUR 65 million to support the digital transition in agriculture, in a paradigm of strong public-private collaboration.
In addition to the interventions foreseen by the RRF, France has developed a strategic plan called France 2030, which is the main instrument to support the country's ecological and digital transition. With EUR 54 billion allocated over 5 years, the plan aims to develop industrial competitiveness and the technologies of the future through 6 levers: guaranteeing access to raw materials, guaranteeing access to strategic components (including electronics, robotics and smart machines), supporting tomorrow's talents by enhancing the educational offer, mastering digital technologies, ensuring the excellence of higher education, research and innovation ecosystems, accelerating the emergence of industrialisation of start-ups that are decisive for the dissemination of innovation.
France Num is the government initiative aimed at the digital transformation of small and medium-sized enterprises (SMEs) and very small enterprises (VSEs) in France. Coordinated by the Directorate General for Enterprise, this initiative involves 70 partners, including all regions and various professional organisations, and benefits from the support of more than 2,500 digital transformation experts, known as France Num Activators. The programme offers free digital diagnostics and training to SMEs and VSEs, promotes the development of best practices and acts as a facilitator for access to financial benefits for digitisation. Through these actions, France Num thus acts as a centralised platform with the objective of demonstrating the benefits of digital technology and accelerating the transition for the country's economic development.
(Source: Italia 5.0 - The skills of the future for the development of innovation in the age of artificial intelligence in Italy and the EU - The European House Ambrosetti, 2024)

In France, the state has moved quickly and forcefully to support the 5.0 transition through grants and public funding for businesses aimed at supporting the following sectors and areas of application:

- Robotics and Automatism: The automation of industrial processes thanks to the use of robots and automated systems.
- Instrumentation of Processes: The use of measurement and control instruments to improve the quality and effectiveness of industrial processes.
- Engineering of Materials: The study and development of new materials to improve the performance of the products.
- Digitalisation of Processes: The use of numerical technologies to improve the efficiency and flexibility of industrial processes.
- Operation Excellence: The optimization of industrial processes to achieve maximum performance.
- Additive Fabrication: The use of 3D impression techniques for the production of pieces and products.
- Réalité Virtuelle, Réalité Mixte, Réalité Augmentée: The use of immersive technologies to improve the conception, production and maintenance of products.
- Integration of Biosource Solutions: The use of biosource materials and processes to reduce the environmental impact of the industry.

Regarding the environmental sustainability part, the government has drawn up a list of fields of intervention:

- Energy efficiency: Minimize your energy consumption and increase competitiveness.
- Eau: Optimize the consumption of the resource in eau, limit the discharges of effluents or improve the treatments.
- Dechets: Enhance the management of your dechets, improve the collection and processing.
- Renewable energies: Integrate the renewable energy solutions, increase energy efficiency and environmental performance.
- Circular economies: Study opportunities, value gains, adopt circular solutions to optimize your performance or adapt your business model to propose circular solutions.
- Economies of functionality: Develop or use integrated solutions of good and privileged services for personalized and adapted usage.

- Ecoconception: Integrate industrial opportunities to minimize environmental impacts from the product conception phase.
- Durable Achats: Evaluate your assets on the value chain, integrate environmental and social criteria into a global life cycle logic in your achats process.
- Adaptation to climate change: Anticipate, adapt your strategies and processes to reduce the vulnerability of your enterprise to the effects of climate change and improve your resilience.
- Décarbonation: Study the solutions for reducing your current carbon, invest in the equipment and processes for CO2 emissions to increase your performances and increase carbon neutrality.

(Source: https://www.fonds-publics.fr/aides/modules-transformants-industrie-5-0)

Even in France there are already some examples of transition 5.0 that are giving results and that deserve to be described as virtuous examples of work and innovation.
In particular, the historical moment of France is that of a new re-industrialization that rests on pillars that marry perfectly with those of Industry 5.0.
The industrialization of France is a crucial step for the next decades. After the 1980s, France underwent a progressive decline in its industrial sector, entering a competitive edge and a wealth of color in its largest regions. The 2020 health crisis has revealed the vulnerability of France to the dependencies of global supply chains, highlighting the need to rebuild a solid and resilient industrial fabric.
The 4 pillars of Réindustrialisation:

- Innovation et Research: Encouraging technological innovation and the development of new industries is primordial to modernize the French industrial sector.
- Training and Competencies: Formerly a main-d'œuvre qualifiée pour les métiers industrials de main est essentiel. There is a pass for the adaptation of educational programs and the promotion of technical threads.
- Investments: Attracting foreign investments and stimulating national investments in innovative industrial projects is a crucial ax to redynamise the economy.
- Durability: Promote an environmentally friendly industry to meet the ecological and economical needs of our era.

Industrialization is accompanied by a number of objectives to overcome obstacles:

- Production methods: Reduce the costs to make French products competitive in the global market.

- Bureaucracy: Simplify administrative procedures to facilitate the creation and expansion of businesses.
- Compétences: Adapter les formations pour répondre aux besoins des industries modernis, notamment dans les domaines de l'intelligelle artificielle et de la robotique.
- Infrastructure: Modernize the infrastructures to support advanced industrial production.

To meet these challenges, several strategies must be implemented:

- Support for innovation: Fund research and development projects in emerging technologies.
- Tax incentives: Offer tax benefits to companies investing in France.
- Public-Private Partnerships: Encourage collaboration between local governments and companies for reindustrialization projects.
- Specialized industrial zones: Develop industrial zones with infrastructures adapted to the specific needs of certain sectors.

(Source: www.pole-implantation.org)

8. Conclusions

The path to the new paradigm of Industry 5.0 has been long and articulated.
On this paradigm, European states are now launching programs and actions to support the 5.0 transition at different speeds to help companies and economic systems evolve and embark on that path that could lead to great development, not only economic but also human and social.

Transition 5.0 is the transition to an advanced, technology-centric industrial model, where the adoption of digital technologies such as IoT, AI, and robotics improves the efficiency, sustainability, and customization of production processes.
This change also requires a review of business practices and a greater focus on human needs. In essence, it is the step towards a highly digitized and future-oriented industry. Industry 5.0 represents a new way of conceiving the economy and industry, a model in which technology and humanity merge harmoniously, creating a balance between efficiency and human values. It is a vision of the industry that not only aims at productivity, but also at the well-being of individuals and respect for the environment. Unlike Industry 4.0, which was configured as a real industrial and technological revolution, Industry 5.0 is above all a new cultural paradigm.

This is why it is essential to help companies, which are the real players in this new paradigm, to understand which path is best suited to their business model, starting from today's starting condition. Models and tools will be needed to understand where we start from and where we want to go, to avoid wasting resources and to make sure that we increase the competitiveness of European companies more and more.

We live in a context of continuous evolution of production systems, skills and processes, technology presents itself as a double challenge: on the one hand, it increases competitive pressure, on the other, it offers solutions to the great challenges of our time, such as the green, social and demographic transitions.

The key to dealing with these changes lies in the development of the paradigm of Society 5.0: theorized in Japan, it represents a paradigm of economic and social development that places man at the center of the synergistic relationship with technology. A step beyond the paradigm of automation typical of the 4.0 world: the goal of the deployment of technology in the 5.0 society is to increase the well-being and quality of life of individuals, putting technology at the service, and not as a substitute, for man.

The 5.0 paradigm is essential for the future of Europe and for the success of the transitions and long-term transformative paths put in place by the European Union.

In this sense, there are two main strategic levers for a successful transition: innovation and skills, without which any technological deployment action is destined, if not to fail, not to maximize its benefits.

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