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INDUSTRY 4.0 TRENDS: A COMPARISON BETWEEN SPAIN AND ITALY

Autor:

Guijarro Hernández, Lydia

Ángel Manuel Gento Municio

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ALUMNO:	Lydia Guijarro Hernández
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CENTRO:	Facoltá di Ingegneria
UNIVERSIDAD:	Universitá Carlo Cattaneo -LIUC
TUTOR:	Violetta Giada Cannas

Resumen

Este proyecto aborda el estudio del nuevo escenario al que se enfrentan y se enfrentarán las organizaciones en los próximos años, la Industria 4.0, un nuevo modelo de negocio en el que encontramos varias herramientas que lo caracterizan y hacen que aporte numerosos beneficios. A su vez, este trabajo se centrará en el estudio y en el análisis de dos potencias económicas mediterráneas, España, e Italia, consideradas como innovadores moderados.

Aunque hay muchos puntos de vista sobre este concepto, todos tienen algo en común: un nuevo modelo de negocio basado en la conectividad de las máquinas y las personas a través de las nuevas tecnologías, consiguiendo una conexión entre lo virtual y lo físico, para mejorar la eficiencia de los procesos y la productividad.

Para ello, uno de los puntos clave, es la correcta implantación en las empresas de las nuevas tecnologías, y la formación de los trabajadores.

Palabras clave

Industria 4.0, digitalización, nuevas tecnologías, DESI e innovación.

Abstract

This project deals with the study of the new scenario that organizations are facing and will face in the coming years, Industry 4.0, a new business model in which we find several tools that characterize it and make it bring numerous benefits. In turn, this paper will focus on the study and analysis of two Mediterranean economic powers, Spain and Italy, considered as moderate innovators.

Although there are many points of view on this concept, they all have something in common: a new business model based on the connectivity of machines and people through new technologies, achieving a connection between the virtual and the physical, to improve process efficiency and productivity.

To achieve this, one of the key points is the correct implementation of new technologies in companies, and the training of workers.

Keywords

Industry 4.0, digitalization, new technologies, DESI and innovation.

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Relatore: Violetta Giada Cannas

Tesi di Laurea di:
Lydia Guijarro
Hernández

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Abstract

This project deals with the study of the new scenario that organizations are facing and will face in the coming years, Industry 4.0, a new business model where we find several tools that characterize it and make it provide numerous benefits. This study will focus on two Mediterranean economic powers, Spain, and Italy.

Although there are many points of view on this concept, they all have one thing in common: a new business model based on the connectivity of machines and people through new technologies, achieving something never seen before: a connection between the virtual and the physical, to improve process efficiency and productivity.

There is an ecosystem around this whole movement, characterized by different digital enablers, driving the digital transformation of the industry. Companies are a key factor in the introduction and even in the training of new generations in this area.

That is why, one of the key points of Industry 4.0 is the correct implementation, as well as the analysis of the factors that have the most advanced companies in digitization, to understand how they work and transfer these methods to other companies or organizations.

Introduction

In this project, the fundamental topic of study will be the extensive world and application branches that the field of industry 4.0 takes.

Each of the industrial revolutions that have occurred over the years have brought about a total and abrupt change. These revolutions have created new technologies and different ways of perceiving the world, causing changes in both economic and social systems.

The first major change was brought about by the domestication of animals. The agricultural revolution brought with it a very high increase in yield and production, thanks to the combined efforts of animals and people. This increase in production was also used to facilitate transportation and communication, increasing food production, and stimulating population growth.

The agricultural revolution was followed by another series of industrial revolutions that marked the transition from muscular to mechanical power. These evolved into the fourth industrial revolution.

The first industrial revolution shifted the world's economy from handicrafts and agriculture to the world of machines. The invention of the steam engine and the construction of the railroad triggered improvements in transportation and communication and the reliance on new energy sources such as coal. New raw materials (steel) also began to be used and labor was divided, leading to the specialization of workers for jobs.

The second industrial revolution occurred in the 19th and early 20th centuries. This was when machines evolved to play a more important role in industry and manufacturers began to use much more synthetic materials.

The utilization of electricity and mass production are two essential elements of the second industrial revolution. Computers were created, giving rise to automatic operations, and incorporating plastics into production lines.

Meanwhile, electronic equipment and information technology systems dominated the third industrial revolution. As a result, manufacturing plants quickly transitioned from analog to digital systems.

In the 1950s, a new style of modernism emerged and spread like wildfire. At this time, automation software made its debut, taking over many of the menial duties traditionally performed by people. This sparked the first major fear that machines will result in vast human unemployment.

Industry 4.0, also called the Fourth Industrial Revolution, holds the promise of a new revolution combining advanced operations and production techniques with new intelligent technologies that will be integrated into companies, organizations, assets, and society.

There are three key gains that a corporation may get by implementing I4.0 technologies: "digitalization of production-information systems for management and production planning, automation-systems for data acquisition from production lines and machine use, and integrating manufacturing locations in a full supply chain"

Furthermore, despite previous revolutions, which mostly focused on economic changes, this time, political and cultural developments played an equal part in how technology revolutionized America and the rest of the globe.

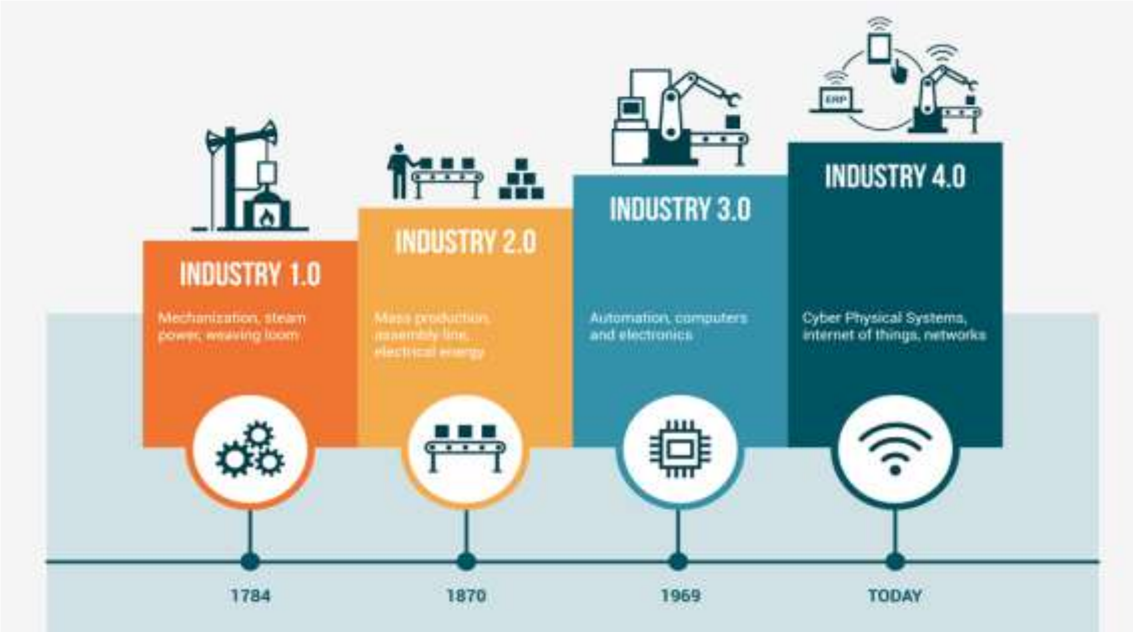

Illustration 1. Different types of industrial revolutions

Image source: M. (2019, 10 October). *The Evolution of Industry 1.0 to 4.0*. Momentum, LLC

With the aid of the Internet of Things, most of these improvements were accelerated and subsequently disseminated internationally. This enabled a hitherto unseen level of interconnection. People were not only aware of events taking place halfway around the world, but their economies were also influenced by them.

Despite its societal ramifications, Industry 4.0 is currently largely focused on production developments. The present manufacturing process is more holistic, incorporating physical and digital elements. This is what gives rise to the cyber-physical environment that defines the current phase of the industrial revolution.

This revolution has enormous potential because it will impact not only industrial processes, but also other industries and sectors, as well as society. Industry 4.0 can revolutionize products, the supply chain, and customer expectations to boost business operations and revenue growth. Such a revolution is likely to impact the way we manufacture things, but it also has the potential to revolutionize how customers interact with businesses and the experiences they expect to have.

Project motivations

As already implied in the introduction, my main motivation is to carry out an analysis of the wide and exciting world of new technologies and how they will influence everyday life.

Before starting this project, I was concerned that Industry 4.0 would be so cutting-edge that it would elude my understanding and prove to be a significant challenge to adapt to; however, these concerns motivated me to overcome my fears and learn everything I could about these new technologies to improve as an engineer and an innovator.

Finally, I believe that the main motivation of this project was to discover numerous electronic devices and processes that are part of our lives and facilitate our daily tasks. The electronic devices that we use to work, study, or communicate with people virtually; virtual platforms or massive data storage, among others, are part of this development and innovation that is essential to know.

Objectives of this project

This project will be carried out in the present project:

- First, an introduction to the world of Industry 4.0 will be made, analyzing the facts that fostered the coining of this phenomenon and the objectives pursued to achieve this industrial digitization.
- The nine pillars of Industry 4.0, the benefits, and barriers to be overcome for its implementation, as well as the main strategic technological trends presented by Gartner will be analyzed.
- Another point to develop is the study on the progress and level of digitization of companies in Spain and Italy, as well as the laws that support and benefit investments in this area.
- Finally, once the characteristics of each country have been described, a comparison is made between the two, analyzing the main features of each country.

Industry 4.0

History of the 4th industrial revolution

The term Industry 4.0 was first used in 2011 at the biggest industrial event, Hannover fair, and the topic has grown every year not only on that fair. This concept was coined by Henning Kagermann, president of the German Academy of Science and Engineering (ACATECH).

From its origin, the German term is used as a synonym for Cyber-Physical Systems (CPS), applied in the domain of manufacturing/production, thus finding numerous definitions for the topic. Analyzing the different definitions, Industry 4.0 can be defined as “a means to increase the competitiveness of the German manufacturing industry through the growing integration of Cyber-Physical Systems (CPS, Cyber-Physical Systems) in manufacturing processes”.

The integration of computation together with physical processes is what is known as cyber-physical systems (CPS). Embedded computers and networks control and monitor the physical processes, usually with feedback loops where physical processes affect computations and vice versa.

This initiative was reflected in a publication of Industry 4.0 Working Group report in 2013, which was carried out by industry professionals, as well as economists and experts in artificial intelligence, promoted by ACATECH. The idea was quickly approved by the German government, as it was seen as an effective way to compete industrially with major world powers such as the United States and Japan.

Because of this, the initiative of Industry 4.0 found a massive support in Germany as well as in other parts of the world. The United States soon followed it and established an industry consortium to foster the Internet of Things in 2014, which was led by industry giants like AT&T, IBM and Intel. In Spain, the autonomous community of the Basque Country was the pioneer in launching its Industry 4.0 initiative and then the Ministry of Industry, Trade and Tourism announced in July 2015, in collaboration with Spanish multinational companies (Banco Santander, Telefónica and Indra), the Connected Industry 4.0 initiative, with budget aid aimed at companies that face the initiative.

Wherewith, in nations with economic and industrial power, Industry 4.0 is one of the key projects as a strategy related to cutting-edge companies implemented in the 21st century; In this analyzed context, it can be seen how the German government in the European Union promotes the digital revolution in the industries of this nation. In the nation of France, entrepreneurs from trading companies such as Oracle, Dassault Systèmes, EADS, and Astrium, are involved in the development of Industry 4.0 in the country. In the United States of America, with the "Smart Manufacturing Leadership Coalition (SMLC)" project, it is also targeting the industrial manufacturing modalities of the future in leading companies on the international market.

It could be said that the fundamental objective of Industry 4.0 is to transform the company into an intelligent organization to achieve better results for the business, i.e., the digitalization of industrial systems and processes, as well as their interconnection through the Internet of things (IoT) to achieve a digital transformation of the industry.

Despite the propagation effort, there are still numerous companies that do not know how to incorporate the advances that this technology implies or how to position themselves.

The nine technological pillars of Industry 4.0.

Nowadays, we are amid the fourth wave of technological advancements. This Industry 4.0 characterized by the rise of new digital industrial technologies is powered by 9 main technologies. This transformation allows connect sensors, machines, and IT systems along the value chain beyond a single company. Cyberphysical systems and these connected systems can interact with one another using standard Internet-based protocols and analyze data to predict failure, configure themselves, and adapt to changes.

Illustration 2: 9 pillars of Industry 4.0

Image source: Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Engel, P., Harnisch, M., & Justus, J. (2021, 12 Abril). *Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries*. BCG Global.

Many of these nine technologies were already used before, but with Industry 4.0 they will transform production. The optimized cells, previously isolated, will come together as a fully integrated, automated, and optimized production flow, thus achieving greater efficiency, and changing traditional production relationships.

Big Data Analytics

The digitized society provides us with automated warehouses of enormous variety of data in actionable formats in real time: control data in production processes that can be considered to reduce costs, customer data to consider for marketing, latest purchases from suppliers, among others.

For instance, semiconductor manufacturer Infineon Technologies has decreased product failures by correlating single-chip data captured in the testing phase at the end of the production process with process data collected in the wafer status phase earlier in the process. In this way, Infineon can identify patterns that help discharge faulty chips early in the production process and improve production quality.

The collection of large amounts of data and the search for trends within the data allow companies to move much faster to innovate products and services and adjust them to market demand.

Big data Analytics is the study of huge amounts of stored data to extract behavior patterns, where big data operate on advanced analytic techniques sets. Hence, this concept is about two things, analytics, and big data, and how teamed up to create one important trend. The size of this data matters, but there are other important attributes of Big Data such as data variety and data velocity.

The three Vs of big data (volume, variety, and velocity) constitute a comprehensive definition, and shows that big data is not only about data volume.

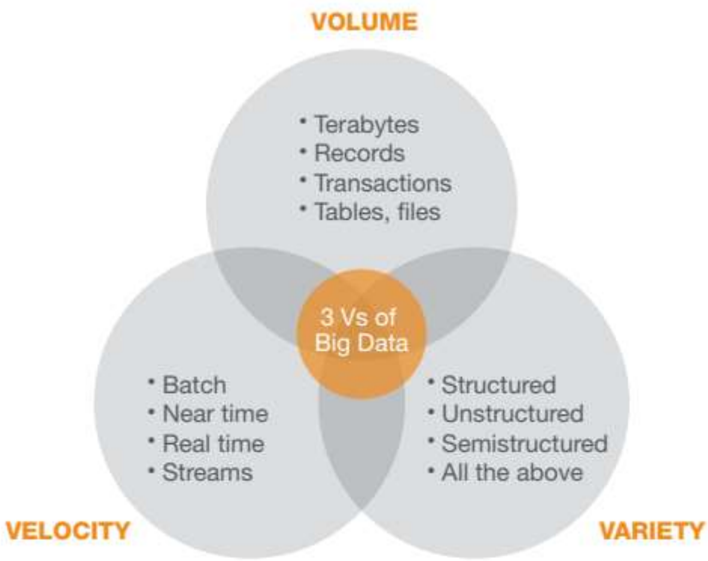

Ilustración 3. 3 Vs of Big Data

Image source: *BIG DATA ANALYTICS*. (2011).

Data volume

It is obvious that the size of the data is an important factor in terms of Big Data, so it is important to consider how to quantify this data. With that in mind, people could define big data in terabytes, and sometimes in petabytes. But it can be quantified also by counting records, transactions, tables, or files. Many organizations find more useful to quantify Big Data in terms of time. It should also be considered that due to the enormous volume; it is difficult to collect, clean, integrate and obtain high-quality data quickly. This is because the unstructured nature of the most information generated by the modern technologies as social networks or weblogs.

Data variety

Another fundamental characteristic of big data is that the data comes from many sources. The newest information collected may come from blogs, online stores, clickstreams, or social media. Of course, user organizations have been collecting Web data for years. However, most organizations had simply accumulated the entire amount of data. Clear examples of untapped big data collected and hoarded can be seen, such as text data from call center applications, semi structured data from various business-to-business processes, and geospatial data in logistics. What has changed today compared to previous years is that now the data is analyzed instead of simply hoarded. Organizations that used to analyze data now do so in a much more sophisticated way. Big data may not be a new thing, but the effective analysis of big data has been a significant change in the way of interpreting data and obtaining relevant information.

The use of these sources means that the structured data, data that previously had an undisputed hegemony in analysis, is joined with the unstructured data (Voice and human text). With which, there is data that is difficult to categorize because of that the greater the volume of data, the greater the variety of data.

Data velocity

Big data can be described by its velocity or speed. It is possible to think of it as the frequency of both data delivery and data generation. For instance, you can think of data flowing in real time, through sensors on a machine in a factory, temperature sensors, or microphones listening for movement in an area. With all this real-time data flow, the volume of data is growing very fast. The complexity is greater if we consider that this data transmission must make sense and take action.

BIG DATA applications

Big data supplies big statistical samples, which enhance analytic tool results. The larger the samples, the more accurate the statistics and the better the statistical survey.

Manufacturing Companies: RFID (radio frequency identification) sensors can be deployed on products to receive telemetry data. Sometimes this is used to offer services of communications, security, and traceability. This telemetry can reveal patterns usage, failure rates, and other product improvement opportunities that can reduce development, production, and assembly costs.

Computing. The use of log records of computer services allows to improve the resolution of ICT problems, as well as the detection of security breaches, and increase speed, efficiency, and prevention of future events.

Autonomous Robots

With industry 4.0 evolution, manufacturers in many industries use more and more robots for complex assignments. Robots have become increasingly flexible, autonomous, and cooperative. Robots may be able to work alongside humans to learn from them and perform more tedious tasks. But it can be advanced to the point that the robots are connected to each other so that they can communicate with each other. Autonomous robots are a seminal example across countless industries, including manufacturing.

By connecting to a central server, database, or programmable logic controller the actions of robots can be coordinated and automated to a greater extent than ever before. Tasks can be completed intelligently and independently of human factors such as fatigue.

The current evolution of robots is growing fast, it is held back by two major barriers: the social problems involved in the implementation of fully robotic factories, as well as the complexity involved in their construction and acting in different situations that may arise.

There have been five generations of robots that have evolved since 1980, year known as “first year of the robotic era”. Robot technology has flow up from a simple microchip to intelligent robots.

The first generation is characterized by the appearance of manipulative robots, which are those that repeat one or more tasks in a programmed manner under software, in sequence. These do not take into consideration the alterations that occur in their environment, they are also used at an industrial level.

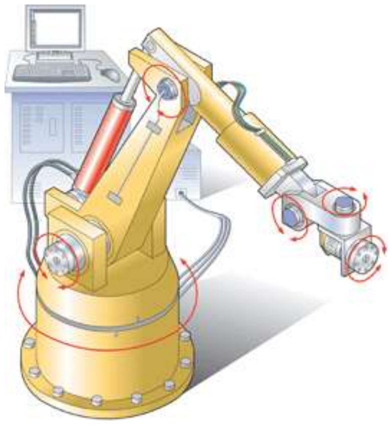

Illustration 4. Example of a manipulative robot

Image source: S. (2017, March 23). *Automatización y control industrial*. RIVAS ROBOTICS - HURTADORIVAS.

Their mechanics systems are made with simple structure. Usually, they are remotely as computer steered by a human operator and replace many human hands.

Within the second-generation robots, we find those that obtained limited information from their environment, they perform the tasks once after learning the movements made by human operators. They have a more advanced technology than those of the first generation, however, the movements are also made accordingly. Specialized sensors and feedback systems make these robots capable of learning different tasks. Through these, robot manages to grasp what tasks he must do, the movements necessary for it are appropriate and check the result of his practice. In this type of robots, the programmer does not need to physically move the element of the machine, when preparing it to perform a job.

In the third-generation robots the biggest change from the previous two generations is that they are reprogrammable by computer. These also have artificial sensors and other parts that allow vision and touch using programming languages. They are also known as robots with sensorized control and are often used in areas where multiple tasks are performed, since being programmable, humans can control their mechanical system as they need to execute each one.

Mobile robots form the fourth generation of robots, which could participate in several process thanks to artificial intelligence. They also have sensors, to which computers send the necessary information during activities. But unlike the previous generation, they are programmed so that they can make decisions and make more movements. These are used in tasks that require various activities and real-time decision-making, just as humans would.

Finally, the fifth generation there are the machines most equipped with artificial intelligence, those with mechanical systems of autonomous reach when performing tasks. Machines are developed with elements that allow them to move, whether they are wheels or artificial legs. Proving useful in construction, manufacturing, design, among other similar tasks.

With the arrival of the fifth generation of robots, machines with more complex elements have been developed, which provide facilities to daily life. Below, some of the most useful types of robots will be mentioned and described.

Domestic: They are the devices that facilitate or do the cleaning and maintenance of the home. Their functionalities are routine. This subcategory also includes robots with other functionalities. Exemplifying, they would be in this part the robots of surveillance or stability. One of the best-known domestic robots today is iRobot's Roomba.

Medical: The categorization of robots in medicine is quite extensive. For instance, there are robots specially designed to assist a lot of types of illness or plasters for breaking of the latest generation. Nanorobots, a type of composite device on a nanoscale (between 0.1 and 10 micrometers) could be integrated into this category. This class of robots are introduced into human bodies intravenously to support in confronting a pathology.

Educative: Its primary function is to help with educational tasks through entertainment. They are mainly used in educational centers and classrooms. The most famous of this part are those of the Mindstorms line of Lego. There are also educational robots that help reinforce cognitive skills such as writing, math, languages or reading.

As mentioned above, there is still a social barrier to overcome for the total implementation of autonomous robots. Obviously, autonomous robots have been a breakthrough in many very important fields of our day to day, performing the most expensive jobs or performing operations with maximum precision.

Simulation

In engineering, 3D simulation has been used for many years to design products, simulate behavior in work plants or for materials. But in the nearby future, simulations will be used more extensively in plant operations as well. The biggest change in Industry 4.0 is that real-time data is now being leveraged to turn the physical world into a virtual world, including machines, products, and even human people. This allows to analyze and thus optimize the configurations of the machines in the virtual world before the physical change. This results in a reduction in setup times and an increase in quality.

The simulation in addition to simply taking data requires a detailed observation of the variables that are of interest and that significantly influence the system to be analyzed, as well as the interactions of these in the system as it constitutes the basis for the establishment of the model and errors in this step would negatively affect the entire process.

Enterprise like Siemens together with German suppliers have developed virtual machines that can simulate some parts of the machines in real time. It was concluded that the simulation reduced setup time by up to 80 percent.

Horizontal and vertical system integration

This concept is one of the fundamental foundations of why Industry 4.0 has gained so much support. Traditionally, management and control systems in industries have been divided into two parts. On the one hand, we do not find management and execution analysis systems, that is, the part of computer systems that can be used in a factory or company. On the other hand, there are the control and supervision equipment, as well as the interconnections that occur between machines or sensors.

Enterprise and costumers are rarely closely linked. If these parts are not connected, it means that departments such as production, engineering, and service either. But with Industry 4.0, companies, departments, functions, and capabilities will become much more cohesive, as cross-company, universal data-integration networks evolve and enable truly automated value chains.

When it comes to horizontal integration, Industry 4.0 envisions connected networks of physical and business systems that introduce unprecedented levels of automation, flexibility, and operational efficiency into production processes. This horizontal integration takes place at several levels:

In the production plant: the machines and production units always connected become an object with well-defined properties within the production network. They constantly communicate their performance status and, together, respond autonomously to dynamic production requirements. The goal is that smart production plants can cost-effectively produce batch sizes of one, as well as reduce costly downtime by predictive maintenance.

In several production facilities: if a company has distributed production facilities, Industry 4.0 promotes horizontal integration into all manufacturing execution systems (Manufacturing Execution Systems - MES) at the plant level.

Across the supply chain: Industry 4.0 offers data transparency and high levels of automated collaboration across the upstream supply chain and logistics that supplies the production processes themselves, as well as the downstream chain that brings finished products to the market.

So, horizontal integration is about digitization across the value and supply chain, with data exchanges and connected information systems at the central place. While horizontal integration is about systems and information flows in the supply chain / value and the various processes that occur through it, vertical integration has a hierarchical level component.

These levels are:

Level 0 - Production process: It interacts with the manufacturing process through all kinds of physically connected sensors, collectors, meters, moving data and continuously measuring the data and variables of the machines.

Level 1 – Sensing and manipulating: At this level logic is programmed, i.e., what will happen to certain signals in the machines or in the system.

Level 2 – Monitoring and supervising: The process line level or the actual production process level (which needs to be monitored and controlled)

Level 3 – Manufacturing Operations Management: Among other things, he is responsible for production planning or quality management.

Level 4 - Business planning and logistics: General planning of orders is carried out.

Data flows freely and transparently up and down at different levels. Below, is the "Automation Pyramid" shown:

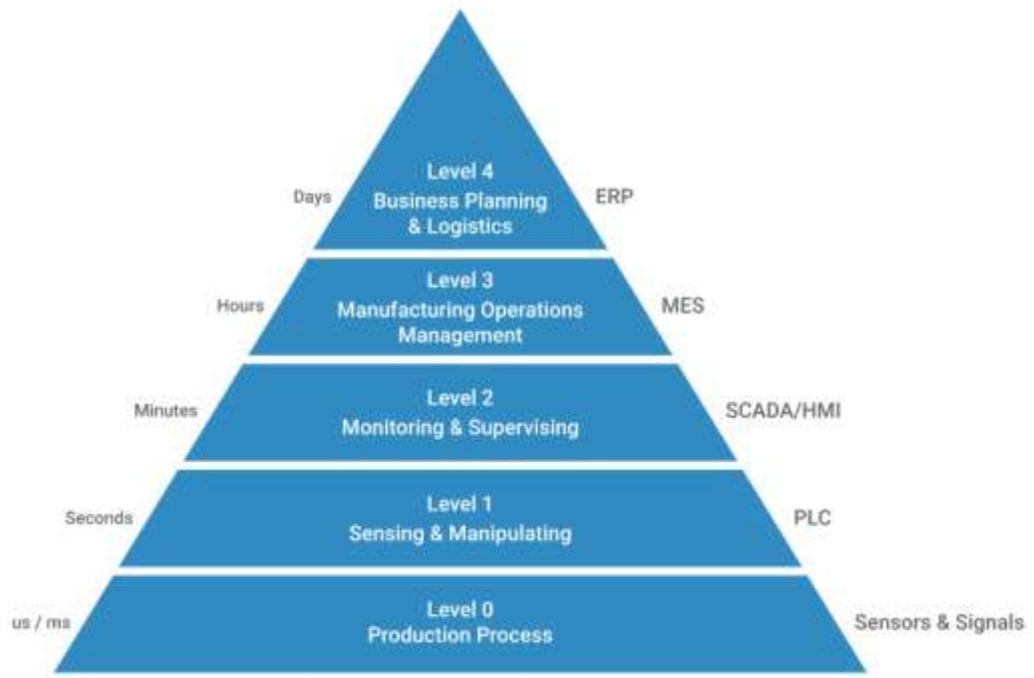

Illustration 5. Automation Pyramid

Image source: *Factory Floor Integration in Industry 4.0*. (2020). Crosser.

Typical vertical integration solutions and technologies include:

PLC (programmable logic controllers) which control manufacturing processes at the control level.

SCADA (supervisory control and data acquisition) which allows various levels of production process and supervisory tasks in

MES (manufacturing execution system) industrial control systems at the managerial level: these software applications support production reports, programming, product tracking, maintenance operations, performance analysis, allocation of resources (personnel and machinery), etc. The manufacturing execution system covers aspects such as plant management and communication with the company's systems (business) Intelligent enterprise-level

ERP (enterprise resource planning), the highest level in the hierarchy.

The industrial internet of things

Today, only some of the sensors and machines are networked and use integrated computing. Typically, they are organized in a vertical automation pyramid in which sensors and field devices with limited intelligence and automation control are introduced into a global control system of manufacturing processes.

With the Industrial Internet of Things (IoT) more devices will be enriched with embedded computing and connected using standard technologies. You can connect objects from our daily lives like cars, domestic applications, or baby monitors to the internet via embedded devices, seamless communication is possible between people, processes, and things.

The cloud, big data, analytics, and mobile technologies can share and collect data with minimal human intervention and low-cost computing. Industrial IoT (IIoT) refers to the application of IoT technology in industrial settings, especially with respect to instrumentation and control of sensors and devices that engage cloud technologies.

Recently, industries have used machine-to-machine communication (M2M) to achieve wireless automation and control. But with the emergence of cloud and allied technologies (such as analytics and machine learning), industries can achieve a new automation layer and with it create new revenue and business models. IIoT is sometimes called the fourth wave of the industrial revolution, or Industry 4.0. The following are some common uses for IIoT:

- Smart cities
- Connected logistics
- Smart digital supply chains

So, thanks to the Internet of Things, field devices can communicate and interact both with one another and with other centralized controllers. It also decentralizes analytics and decision making, enabling real-time responses.

Cybersecurity

With the increase in technology and connectivity that Industry 4.0 has brought, the need to protect industrial systems, manufacturing lines and people connecting to the internet has increased considerably. Consequently, a protected identity, machine access management and secure connections are essential for the smooth operation of Industry 4.0 technologies.

With this need to protect systems, the concept of Cybersecurity is born. This term refers to the practice of protecting networks, systems, or programs from digital attacks. These type of cyberattacks are normally aimed at accessing, changing, or destroying sensitive information; extorting money from users; or interrupting normal business processes.

It is also known as information technology security or electronic information security. The term applies in different contexts, from business to mobile computing, and can be divided into some common categories.

The **security of the information** protects the privacy of the data and its integrity, both in the storage and in its use.

Application security focuses on keeping software and devices free of threats. An affected application could provide access to the data it is meant to protect. Effective security begins at the design stage, well before the implementation of a program or device.

Network security is based on protecting the computer network from intruders.

Operational security includes the processes and decisions to manage and protect data resources. The permissions that users must access a network and the procedures that determine how and where data can be stored or shared are included in this category.

Recovery from cyber-attacks, as well as business continuity, define how the organization can respond to security attacks or any other event that stops its operations. Business continuity is the plan the organization uses when trying to operate without certain resources.

After analyzing the different categories of security, an analysis will be made of the types of cybersecurity threats.

Malware refers to malicious software. It is one of the most common cyber threats, created by a hacker or cybercriminal to interrupt or damage a computer. It is usually spread through email attachments, or links to websites. The malware can be used by cybercriminals to make money or to carry out cyber-attacks to get information.

There are different types of malwares, including the following:

Virus: a program capable of reproducing, spreads throughout the computer system and infects files with malicious code.

Trojans: A type of malware disguised as legitimate software. Cybercriminals trick users into loading Trojans onto their computers, where they cause damage or collect data.

Spyware: a program that secretly records what a user does so that cybercriminals can make use of this information. For example, spyware might capture credit card details.

Ransomware: malware that blocks a user’s files and data, with the threat of deleting them, unless a ransom is paid.

Adware: software de publicidad que puede utilizarse para difundir malware.

Botnets: Computer networks with malware infection that cybercriminals use to perform online tasks without user permission.

Phishing

Phishing is when cybercriminals attack their victims with emails that appear to be from a legitimate company requesting confidential information. Phishing attacks are often used to induce people to give up their credit card details and other personal information.

For instance, Malware Dridex is a financial trojan that has different functionalities. Since 2014, it affects victims and infects computers through phishing emails or existing malware. It is capable of stealing passwords, bank details and personal data that can be used in fraudulent transactions and has caused massive financial losses amounting to hundreds of millions of dollars.

In December 2019, the United States Department of Justice (DoJ) indicted the leader of a group of organized cybercriminals for his involvement in a global Dridex malware attack. This malicious campaign affected the public, government, infrastructure, and businesses around the world.

The cloud

Some companies already used cloud-based software for some data analysis or to perform more complex operations. "The cloud" refers to the servers accessed over the Internet, and the software and databases running on those servers. Cloud servers are in data centers around the world. It allows access to the same files and applications from virtually any device, as, storage takes place on servers in a data center and not on a local device.

CLOUD COMPUTING

With the rise of Industry 4.0, cloud computing is an ascending technology that has introduced a new paradigm by making a rational computational model possible. This is due to the need to interconnect companies involved in a value chain.

Virtualization makes cloud computing possible by creating a virtual, simulated, and digital computer that behaves as if it were a physical computer with its own hardware. This computer is also known as a virtual machine. Virtual machines on the same server computer, when implemented correctly, despite being located on the same physical machine, do not interact with each other and files and applications of a virtual machine are not visible to other virtual machines.

In general, even if individual servers fall, cloud servers will still be online and available. Generally, cloud providers back up their services on multiple machines and in multiple regions.

Users access cloud services through a browser or application, which connects to the cloud over the Internet, that is, through many interconnected networks, regardless of the device they are using.

Additive manufacturing

Companies have started to embrace additive manufacturing among which 3D printing stands out in a preeminent way as they enable many custom products as well as construction advantages.

The 3D printer or rapid prototyping machine is known to be capable of, from a virtual design of a three-dimensional object, carry out the elaboration of said object by depositing material obtaining as a result that virtual object in a real object.

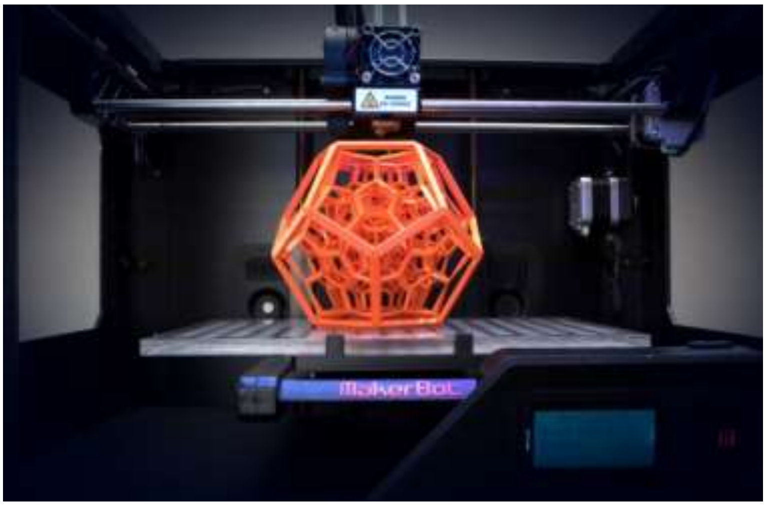

Illustration 6. Example of 3D printer

Image source: Team, N. P. A. (2022, April 9). *Will 3D Printing Technology Replace Traditional Manufacturing?* ParametricArchitecture.

One quality that three-dimensional printers have is that when it comes to creating the object, it does not remove material from a block or is based on the use of molds, but for its elaboration what it does is to deposit material on the model itself under construction.

This feature what contributes to the final element is that forms are achieved with greater flexibility when manufacturing complex geometries, on the other hand cheaper processes by dispensing with elements such as molds, leftover material...

For instance, companies involved in manufacturing aerospace spacecraft parts have quickly adopted 3D printing as it allows parts to be made with a much lower weight and reduce costs on raw materials such as titanium. This makes parts much more ergonomic and flexible.

Augmented reality and virtual reality

Virtual reality (VR) and augmented reality (AR) are reality technologies that either enhance or replace a real-life environment with a simulated one.

Augmented reality (AR) can be defined as a real-time direct or indirect view of a real-world physical environment, which has been enhanced or augmented by adding a series of virtual computer-aggregated information. Through one or more devices, this virtual information is added to the physical information perceived by natural vision. Tangible physical elements combine with virtual elements and create real-time augmented reality.

Virtual reality (VR) consists in producing by computer programming an environment that appears to the eyes of the user as real and immersed in it through the appropriate hardware equipment (three-dimensional glasses). It is used in the industry for immersive process learning and in marketing for the immersive promotion of products for sale.

In AR, el espacio virtual coexiste con el real, con el fin de proporcionar algún tipo de información adicional sobre el mundo real. Virtual reality creates a complete simulation that replaces the real world with a fully virtual world.

So, we can clearly see the differences between both types of reality. In virtual reality the user isolates himself from the material reality of the physical world to immerse himself in a scenario or totally virtual environment. The user almost always wears an eye-covering headset and headphones to completely replace the real world with the virtual one. The goal of VR is to eliminate the real world as much as possible.

On the other hand, augmented reality combines the virtual world with the real one, most of the time the user needs a smartphone or tablet screen to accomplish this, point the phone camera at a point of interest and generate a live video of that scene in the screen. Then on that screen useful information appears, including implementations such as navigation information, or diagnostic data.

AUGMENTED REALITY APPLICATIONS

Applications at the industrial level come from the synchronization between the objects of interest on which the operator fixes his gaze and the previously stored information of operating procedures. Some possible examples would be:

-Alerts of defective parts in quality control.

-Reminder of possible hazards in certain areas of the plant.

-Warnings of preventive maintenance tasks in the event of remote detection of breakdown risks.

-Description of the contents of closed packages in the warehouse or shelves.

-Detection of products or parts in poor quality at the reception of these. -Notice of maintenance on a machine by wear or failure in a part.

-Reminder of preventive maintenance of a machine.

Although robots will become increasingly autonomous, employees will continue to play a role thanks to being equipped with augmented reality goggles that can offer logistics and manufacturing information in their field of vision. For example, the glasses will use augmented reality to highlight the location where each part must be mounted in the assembly process.

VIRTUAL REALITY APPLICATIONS

Virtual reality has numerous applications in terms of video games or forms of entertainment. When we talk about companies some of the most significant examples are:

-Architects use VR to design houses, so customers can "walk through" their own homes even before it is built to know if they really want the design to be like that.

-Most vehicles are designed with VR

-Can be used to simulate dangerous environments, for sports or soldiers.

Barriers to I4.0 and benefits of I4.0

The evolution and boom of Industry 4.0 can bring companies numerous advantages in many respects. It can be beneficial in adapting to new market and consumer demands or in making increasingly intelligent decisions. Some of the most outstanding advantages are:

- There is an optimization of the processes carried out in the factories, resulting in a decrease in the time of these
- More refined, repetitive, and error-free processes are obtained, as the defective parts are eliminated thanks to artificial intelligence.
- Greater cost savings are achieved because of greater efficiency. Automated processes allow the use of fewer personnel, fewer errors and greater efficiency of raw materials, energy, etc.
- Production times are drastically reduced.
- Digitization provides greater security for the personnel involved in each process.
- Business competitiveness is higher and can respond to the needs of markets with higher quality products, faster and more flexible to change.
- The traceability of day-to-day records generated because of the business management process is increased.
- The analysis of data is much more efficient, being able to define people authorized to access and interact from anywhere.

Whereby, Industry 4.0 implies the convergence of a set of approaches and new technologies to which, as an industrial country, it is essential to bet with determination. A study carried out by the consultancy firm McKinsey revealed that the increase in productivity derived from this new technology could mean around 45%-55% increase in flexibility, cost, quality in the manufacturing environment and competitive advantage.

However, a recent analysis by the consultancy firm Deloitte revealed that of the managers of a sample of European companies analyzed, only 14% said that their organizations were prepared to incorporate these changes. In another study, only four out of 10 companies had made progress in their implementation. So, the road to effective implementation of these technologies is not proving so easy, due to several difficulties.

- At present, changes in new technologies are becoming increasingly rapid and many companies are not adapting to new methods at a rapid pace. Because of this, many companies run the risk of becoming outdated or outdated.

- We still lack precise knowledge of the potential of these technologies, and consequently of the strategic importance they may have for the medium/long term future of companies.

- Making these processes effective requires trained people. Nowadays, the lack of training by people and managers in this technology is very noticeable.

- Rapid industrial progress can lead to growing inequalities and social fragmentation.

- The cost of the investment is high, especially at the beginning, so not all companies can afford this investment. But we must bear in mind that in the medium and long term the investment recovers.

- Governments and legislation do not always change and evolve at the same speed as industry and technological advances.

Current trends (2021-2022)

The consulting firm Gartner, leader in the information technology research sector, gives us a much clearer view of current trends in Industry 4.0 with each of its studies since it is exclusively dedicated to research and analyze market trends. According to Gartner Industry 4.0 is "an appropriate framework to enhance the digitization of the value chain, efficient collaboration between companies, the Internet of Things, technology providers and consumers".

The Covid 19 pandemic has marked a great discontinuity in many aspects of society and business, with the technologies that are currently being used to deal with this pandemic decisive for the transformation of businesses and companies in the coming years. As Gartner says, we may find ourselves facing a pandemic or a recession, but volatility is part of this world and only those organizations that know how to adapt to the different changes will be able to overcome any type of disruption in the future.

Gartner's top strategic technology trends really provide a framework for IT leaders to help review and prioritize their investments in technology. These trends matter because they help drive key business priorities. For 2022, there are 12 top strategic technology.

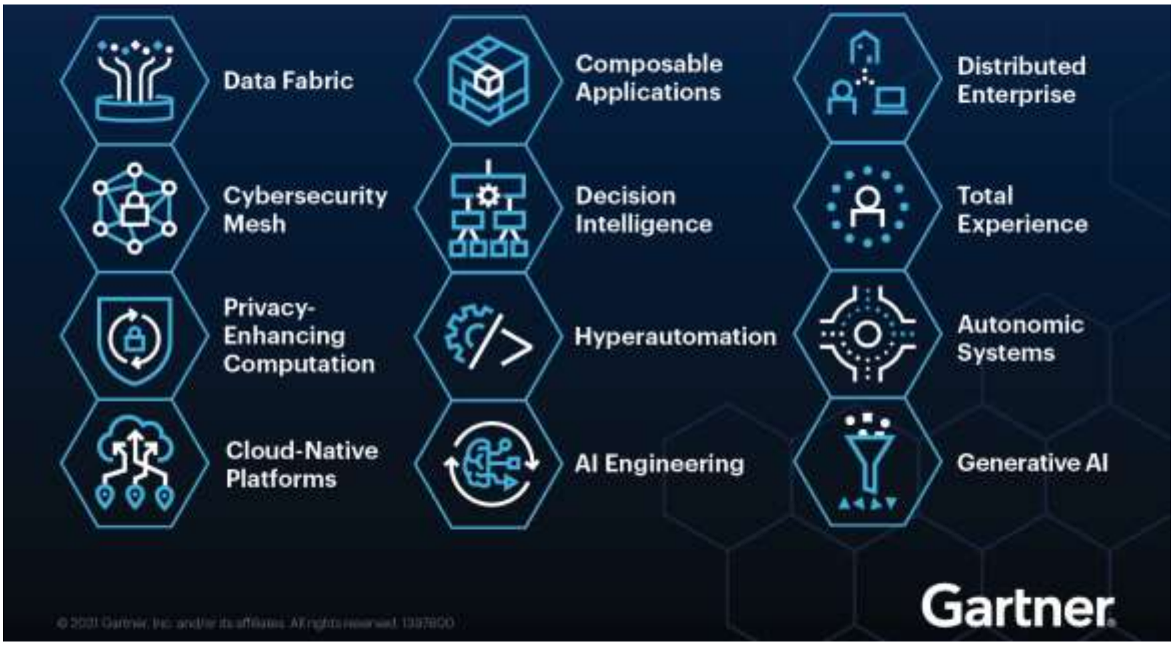

Illustration 7. Gartner's top strategic technology trends in 2022.

Image source: *Top Strategic Technology Trends for 2022*. (2022). Gartner.

Every business leader wants a competitive edge. These 12 compelling technologies will accelerate digital capabilities and drive growth over the next 3 to 5 years and will deliver trusted digital connections for people and devices, solutions to rapidly scale digital creativity anywhere, and innovate capabilities to accelerate business growth.

Then, these trends will be defined as well as the reason for their importance.

1. Data Fabric.

The data fabric provides flexible and resilient integration of data sources across platforms and business users, so they are available from anywhere they are needed and wherever they are staying.

The data fabric can use analytics to actively know and recommend where the data should be used and changed. It can reduce data management efforts by up to 70%.

2. Cybersecurity Mesh.

It is a flexible architecture that integrates distributed and disparate security services. This is not a technology problem, it's business problem for every organization today, as virtual operations and relationships distribute activities and data far wide.

It offers the best security solutions regardless of whether they are used together for overall protection or whether control points are closer to the assets to be protected.

3. Privacy- Enhancing Computation.

This trend ensures the processing of personal data in environments that may not be entirely safe. This is a fundamental issue today in the face of regulatory changes in terms of privacy and data protection, as well as the growing concern of consumers for the use of their data.

Privacy-Enhancing Computation uses techniques that allow us to obtain value from the data while complying with current requirements.

4. Cloud-Native Platforms.

Cloud-Native Platforms are a set of technologies to accelerate and enhance cloud computing thanks to their ability to build new elastic, resilient and agile application architectures to adapt to the rapid pace of digital development.

This enhances the traditional "lift-and-shift" (or rehousing) approach, which does not take full advantage of the cloud and adds complexity to maintenance. Lift-and-shift has been taking on premise or legacy applications and moving them to the cloud. However, this platform offers new sets of technologies. These are cloud optimized architectures that allow for the use of modern languages and modern frameworks, that make it easier and accelerate digital business delivery.

5. Composable Aplications.

Composable applications are built from modular business-focused components.

Component applications make it easy to use and reuse code, speeding time to market for new software solutions and unlocking business value.

6. Decision Intelligence

Decision Intelligence uses artificial intelligence to filter out the noise and focus on what you need to see within the business context. The performance of companies is greater when they make better decisions than their competitors, each of these decisions is modeled as a set of processes, using the knowledge and analysis to shape the decisions and thus be able to improve them.

7. Hyperautonomation.

This technology is a professional approach that seeks to quickly identify, understand, and automate as much business and information technology processes as possible. It facilitates business model transformation and remote operations.

8. AI Engineering.

Artificial intelligence engineering automates data, model, and application updates to streamline AI delivery.

Combined with strong AI governance, AI engineering makes AI delivery operational to ensure continued business value.

9. Distributed Enterprise.

These types of enterprises reflect a model that prioritizes the digital and the remote to improve employee experiences, digitize the contact points of consumers and partners, and develop product experiences.

Distributed Enterprise can satisfy the demands generated by consumers and remote employees, who increasingly demand more services virtually.

10. Total Experience.

This business strategy integrates into it a series of experiences; employee, customer, user experience and multi-experience at numerous points to accelerate growth.

This experience increases product knowledge, trust, loyalty, and customer advocacy through a holistic management of the experiences of each stakeholder.

11. Automatic Systems

These systems can be managed physically or by software and are able to learn from their environment and modify algorithms in real time to optimize behavior.

Automatic systems create an agile set of technological capabilities that can help in case of new requirements and situations, optimize performance, and defend against attacks without the need for human intervention.

12. Generative IA.

The Generative IA uses data to learn how artifacts are and generate innovative creations that are not the same as the original. It has the potential to produce new forms of creative content, such as videos, or to accelerate I+D cycles in a wide range of fields ranging from medicine to product design.

These technology trends will accelerate digital capabilities and drive growth as they solve common business challenges for CIOs and technology executives.

Industry 4.0 in Spain

Incorporation of Industry 4.0 in Spain

With the evolution of new technologies, a change in the manufacturing sector emerged at the beginning of this century, a change that many experts have described as a great revolution. The main pillars on which this industry began to be built have been mainly the following:

- Digitisation of processes.
- Online shops.
- Digital services.

Thus, this revolution is rooted in the digital revolution. We see a more ubiquitous and mobile Internet, supported by smaller and more powerful sensors, as well as artificial intelligence and machine learning. It must be said that Industry 4.0, in Spain and the rest of the countries, has laid its foundations on the cloud and the Internet, offering all kinds of services through the network.

Indeed, the cloud and the internet occupy a physical place with billions of meters of fibre optic cables and numerous telecommunications stations around the world. The fourth industrial revolution is building its services on this network, which has been in place since the last century, to add value.

For example, moving from an offline shop with a limited reach to an online shop with global coverage brings value to the user, increasing the offer in their locality. Without the wiring that telecommunications companies have built, none of this is possible.

Another key factor, which has been fundamental in promoting innovation and implementing Industry 4.0, is that nowadays costs are much lower in terms of IT, but above all in terms of storage.

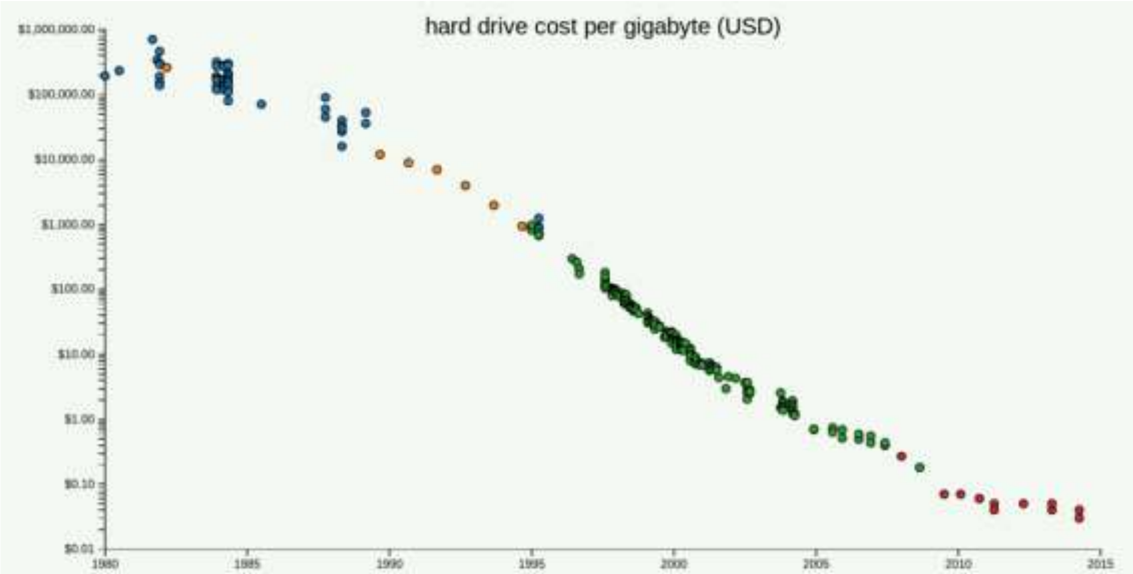

Illustration 8. Example hard drive cost per gigabyte.

Image source: Clever. (2018, April 6). *Hard Drive Cost Per Gigabyte (USD)*. Clever Engineering Blog.

It can be seen from the graph above that in the early 1980s the cost of storing one GB of data was approximately $1,000,000, whereas these days, thanks to advances in technology, you only must pay a few cents for it. Industry 4.0 therefore takes advantage of this situation to be able to create new sectors and offer improved services.

Research in Spain enjoys international prestige, as it is easy to find numerous headlines in which Spanish scientists and researchers have made important discoveries in the last century. Although the process of implementing digitalization and new technologies in Spain is slow, it is progressing steadily and progressively. Currently, approximately 32% of companies are at an advanced stage in the implementation of new technologies, while 68% are at a medium or low stage.

With these data, companies can be classified according to their level of digitalization. Thus, in Spain, 21% of industrial companies are digital novices (they are in the initial phase of digitization), 47% are digital followers (they have a few digitized and connected functional areas) and 27% are digital innovators. Only 5% can be considered digital champions (they are fully digitized and have it fully integrated throughout their value chain: from their production processes, through their human resources, their commercial aspects and their relationships with customers and suppliers).

Laws for digitalization.

It will be explained below the different plans and laws to boost digitalization in Spain.

- Digital Spain 2025.

The Digital Spain 2025 is key to bridging the digital divide between small and medium-sized enterprises by improving digital skills in companies and training workers to achieve business goals. This plan, approved by the government, aims at the economic growth of companies.

Previous action plans such as the Info XXI Plan, the España.es Program, the Avanza Plan and, lastly, the Digital Agenda for Spain of February 2013 have formed a strategic basis for guiding a major public and private investment effort in this area.

Most of the digital strategies and agendas so far have been articulated around four main lines of action: “the digitalization of the economy; the deployment of networks and services for digital connectivity; improving electronic government; and training in digital skills.”

Thanks to all these plans and programs, Spain's position when it comes to tackling the next phase of the country's transformation is very advantageous, as it has a good infrastructure network and leading companies in very important sectors such as healthcare, mobility, and tourism. The country also has a good digitization of the Administration and has a formidable potential in the application of new technologies to the management of information and the execution of public policies.

However, in the field of digitization of industry and business, especially SMEs, in I+D+I, and in the social capacity to adapt to digitization, this progress has been more limited. These are three key concepts for Digital Transformation to produce an increase in productivity, development opportunities and improved connectivity.

The exceptional situation resulting from the COVID-19 pandemic has made it necessary to accelerate the digitalization process, highlighting the strengths as well as the shortcomings from an economic, social, and territorial point of view. It is known that, in Spain, during the mobility restrictions, fixed voice increased by 50%, mobile voice by 30% and mobile data traffic by 50%. In addition, digital audiovisual services have taken on great relevance, as they are considered a generalized consumer good in leisure and entertainment, being an accessible alternative to maintain those activities affected by restrictions on physical mobility.

This agenda consists of approximately 50 measures, reforms, and investments, articulated in ten strategic axes, aligned with the digital policies set by the European Commission for the new period.

1. Digital Connectivity

It aims to ensure adequate digital connectivity for the entire population, promoting the disappearance of the digital divide between rural and urban areas. Connectivity, through infrastructure networks, to achieve adequate data transmission between citizens, companies, and the Administration, is a fundamental part of digitalization and of the territorial, social and environmental structuring of the country, as it is the key to access for the entire population to the services and opportunities derived from it.

As previously mentioned, the COVID-19 pandemic has made it necessary to accelerate the digitalization process, and the health crisis has also highlighted some aspects that need to be improved to achieve equal opportunities and access to networks for all territories.

Digital Transformation is a process that is accelerating in all economic sectors worldwide, which is accentuating the need for global interconnection and infrastructures through which a large volume of data flows to be stored.

To achieve all these improvements and advances, it is necessary to reinforce and reorient the available instruments to extend internal connectivity and the active integration of Spain in cross-border infrastructures to achieve quality global connectivity, following the next objectives:

- Promote a social, economic, and territorial structuring of the country, ensuring that infrastructures are uniform in all territories, types of companies and socioeconomic groups.
- Eliminate the social inequality gap generated by the lack of access to or use of the Internet.

The goal is for 100% of the population to have 100Mbps coverage by 2025.

2. Promoting 5G Technology.

This strategic axe goes beyond the development of a new generation of mobile telephony, as it may open yet totally unknown opportunities for industrial transformation.

In this scenario of national economic reconstruction, the deployment of infrastructures and high-capacity networks is one of the key points for the creation of employment and consumption. For this reason, Spain Digital 2025 aims to make Spain the highest quality 5G testing and development platform in Europe, while actively collaborating in the European Commission's plans to promote the participation of Member States in the development of 6G.

The target set for 2025 is for 100% of the radio spectrum to be 5G-ready.

3. Digital Skills

Firstly, to reinforce the basic digital skills of citizens to be able to operate with confidence when communicating, getting information, or performing any type of interaction. Secondly, more advanced skills are required for more complex activities such as programming or sophisticated content search. The current digital skills gap for citizens, the working population and specialists is notable, and requires joint actions between the public and private sectors to close it.

To achieve this, special emphasis will be placed on the needs of the labor market and on closing the digital divide in education.

One of the measures taken has been the National Digital Skills Plan, which aims to: raise the level of basic skills among today's most disadvantaged groups; ensure advanced digital skills for secondary school leavers; train workers with the skills needed for their jobs and possible future work, increasing productivity; and meet the demand for general practitioners.

This is intended to ensure e-inclusion and advance development basic competencies of citizenship, so that all people be able to use digital technologies autonomously and adequately.

By 2025, the aim is for 80% of people to have basic digital skills and for 50% to be women.

4. Cybersecurity

The Digital Transformation offers numerous opportunities for socioeconomic development, but at the same time incorporates risks and threats related to digital and Internet security. To mitigate this risk, it is essential to develop the cybersecurity capabilities of citizens, companies, and public administrations.

The objective for 2025 is to increase to 20,000 the number of specialists in cybersecurity, Artificial Intelligence, and data, reinforcing the Spanish cybersecurity capacity.

5. Digital transformation of the public sector

The path towards a data-driven Public Administration is led by technologies such as blockchain, Artificial Intelligence or the export of a large volume of data through big data. Today, there is a demand for services that are much more personalized, easier to use and adapted to needs, which leads to an increase in requirements in terms of security levels and the environment. Within this framework arises the commitment to transform the digital relationship with citizens and companies through the modernization of digital services provided by public administrations.

The aim is that by 2025, 50% of public services will be available on a mobile application, and that they will have a more personalized relationship between citizens and companies with the Administrations.

6. Digital transformation of business and digital entrepreneurship.

The transformation of companies to adopt new processes, investing in technologies and in the training of their personnel helps to achieve an increase in productivity, competitiveness, and future profitability. Some of the specific objectives within this modality are:

- Accelerate the Digital Transformation of SMEs by strengthening networks of innovation support capabilities for digitization.
- Promote digital entrepreneurship, both national and international, residing in Spain.
- Strengthen and boost the number and size of start-up investments.

To achieve these objectives, the Spanish Government has launched a series of plans, including the SME Digitalization Promotion Plan. Digitalization translates into a significant increase in their productivity.

The aim of these strategies and investments is to ensure that by 2025 at least 25% of SME turnover comes from e-commerce.

7. Projects to drive sectoral digitalization.

It aims to accelerate the digitization of the production model through digital transformation projects in strategic economic sectors such as health, mobility, agri-food, tourism, trade, and energy, among others. These projects aim to reduce CO2 emissions by 10% because of the digitalization of the economy by 2025.

8. Spain magnet for investment and talent in the audiovisual sector.

In recent years, the audiovisual sector has experienced strong growth, becoming a strategic activity from an economic point of view and, at the same time, a powerful vehicle for the representation of cultural diversity and the transmission of values, as well as a generalized consumer good in the leisure and entertainment of all of us.

The aim is to attract investors to turn Spain into a pole of attraction for the audiovisual sector. It is also essential to reduce audiovisual production costs and improve competitiveness. The aim is to achieve a 30% increase in audiovisual production in Spain by 2025.

9. Economy and artificial intelligence.

Transition to a data economy, guaranteeing security and privacy and taking advantage of the opportunities offered by Artificial Intelligence with the goal that at least 25% of companies will be using Artificial Intelligence and Big Data within five years.

One of the most relevant measures is the National Artificial Intelligence Strategy. This will contain measures to promote the development and adoption of AI in Spain, as well as others aimed at increasing its reliability. The Strategy will be configured as a "living" Strategy, with periodic reviews, so that it can be flexibly adapted to the needs and changes that occur in such an evolving technology as AI.

10. Digital Rights.

Because digital technologies are profoundly changing our daily lives or the way we relate to other people, there are proposals to strengthen citizens' rights in the new digital environment. Proposals also focus on guaranteeing labor, consumer, citizen, and business rights. Finally, the objective in this area is based on the elaboration of a charter of digital rights.

In conclusion, Digital Spain 2025 is a roadmap to guide the transformation and reduce the digital divide within the country and between countries.

Once the most current digitalization plan in Spain has been analyzed, including the objectives and measures that will be implemented to achieve these objectives, the set of regulations carried out by the Ministry of Science and Innovation and other organizations oriented to research, development and innovation (R&D&I) in Spain, as well as the Spanish scientific and technological infrastructures and facilities, will be presented.

- Science Act of 1986

This law, known as “Ley 13/1986 de Fomento y Coordinación General de la Investigación Científica y Técnica”, managed to place science on the Spanish political agenda for the first time, laying the foundations for research, as well as its financing, organization and coordination between the State and the autonomous regions.

The regulation of this plan led to the birth of the national research plan as an "instrument for financing science". It also meant that multiple public research organizations could create companies, to encourage companies that dared to promote and invest in new technologies and in the disconnection of the science-technology system with the productive system.

- Science, Technology, and Innovation Law (2011)

This law was approved by a parliamentary majority on May 12, 2011, with the aim of consolidating and internationalizing Science in Spain and was promoted to replace the 1986 law, since a large part of the population stated that the law no longer contemplated the current R&D&I panorama and that a new law was needed that would be better adjusted to the current context of research and development.

The main objectives and challenges that this law is intended to meet are as follows:

- Modernize and internationalize the Spanish research system.
- Establish a general framework for the promotion and coordination of scientific and technical research.
- To favor a greater role for private initiative in research, as sources of finance are needed, and sometimes public funds are not enough to start up.
- Contribute to sustainable development and social welfare through the generation and dissemination of knowledge and innovation.

In short, this law aims to generate knowledge and transfer this knowledge to the productive sector.

The main new features of this law compared to the previous one are as follows:

- A commitment to promoting the participation of the private sector in the financing and execution of R&D&I activities.
- Before the approval of this law, the personnel working in healthcare centers that carried out research processes were not considered researchers. But with this law they are considered as such.
- The creation of an independent advisory body that monitors research malpractice.

Although this law was necessary and long awaited, it has been criticized for not contemplating the careers of technologists, research support personnel and management personnel; the researcher's career follows the classic functional model.

In conclusion, the "Ley CTI" provides a legal framework adapted to the 2011 context of R&D&I in Spain and although it was much needed, it did not meet many of the expectations about it.

- Science Act of 2022

In 2020, the Ministry published the pre-consultation on the amendment of the 2011 Science Act. On 18 February 2022, the Council of Ministers approved the referral to the Courts of the Bill amending the Law on Science, Technology, and Innovation, which provides more resources, rights, and stability to the staff of Research, Development, and Innovation (R & D & I).

The text incorporates the commitment by law to achieve public funding in R&D&I of 1.25% of GDP by 2030, which, with the support of the private sector, will make it possible to reach the 3% established by the European Union. The regulation introduces reforms aimed at reducing precariousness, providing stability to researchers, and attracting talent.

Digital Economy and Society Index in Spain

To monitor and thus keep track of the digital progress of the EU Member States, the European Commission has been publishing annual Digital Economy and Society Index (DESI) reports since 2014. It helps Member States to identify areas for priority action by providing EU-wide analysis in key digital policy areas.

In 2021, the Commission designed the report to reflect the two main policy initiatives that will affect digital transformation in the EU over the coming years: the EU Digital Decade Resilience and Recovery Mechanism and the EU Digital Decade Digital Compass.

So, Spain's technological progress can be seen by analyzing the DESI report, which tracks the progress made by EU Member States in digital competitiveness in the areas of human capital, connectivity, the integration of digital technologies and digital public services.

The DESI 2021 report shows data for the first and second quarter of 2020, thus providing information on the onset of the pandemic. To date, all Member States have met the target of allocating at least 20% of their national envelopes to the digital domain.

	Spain		EU
	rank	score	score
DESI 2021	9	57.4	50.7

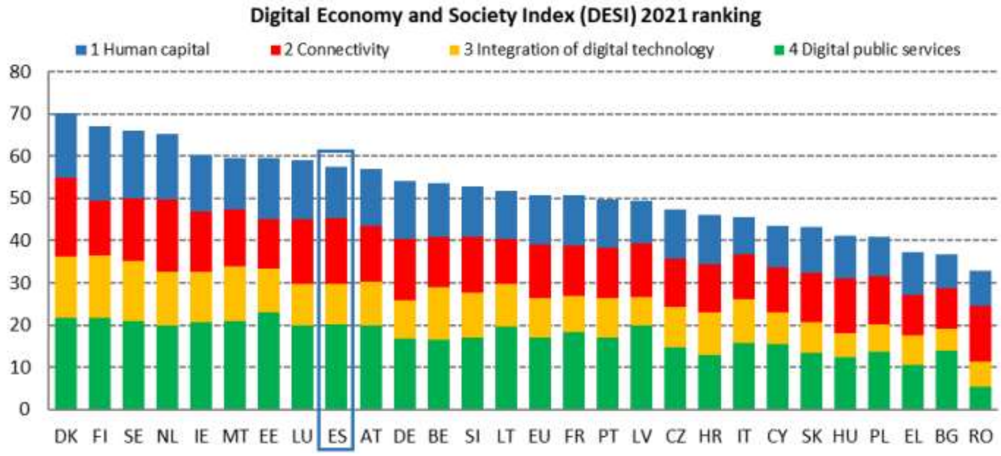

Illustration 9. Spain's ranking in the DESI

Image source: *Digital Economy and Society Index (DESI) 2021 Spain*. (2021)

The DESI 2021 ranking is headed by countries such as Denmark, Finland, and Sweden, followed by the Netherlands, Greece, Bulgaria, and Romania.

Spain ranks ninth out of 27 Member States. Although this is a very good result, there are aspects that need to be improved. Lack of training in basic digital skills, SMEs (Small and Medium-size Enterprises) lagging in digitization and a shortage of ICT specialists are the main factors holding back digital progress in Spain.

In 2020, Spain adopted the ambitious new digital agenda described above, Digital Spain 2025, which aims to drive the country's digital transformation through a series of reforms to be implemented by 2025, as well as through significant public and private investments.

Within the framework of this agenda, additional specific plans have been launched in areas such as human capital, connectivity, and the digitization of companies.

In early 2021, a National Digital Skills Plan was presented, setting out a detailed set of measures aimed at strengthening the digital skills of the workforce and citizens in general. Spain is currently performing average in the human capital dimension and this strategy will help its people to take better advantage of the opportunities offered by the digital economy and society.

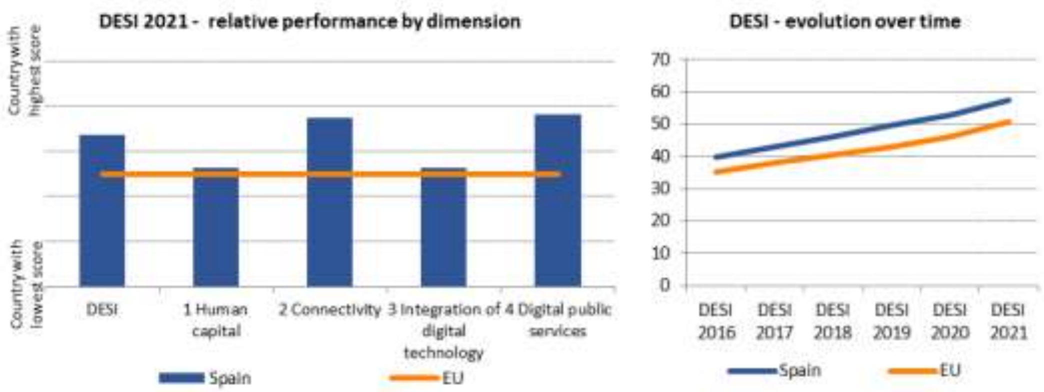

Illustration 10. Relative performance by dimension and evolution over time in Spain

Image source: *Digital Economy and Society Index (DESI) 2021 Spain*. (2021)

Recovery and Resilience Plan (RRP) is a project developed by the Spanish Government that outlines a roadmap for modernizing the country's economy, economic growth, and job creation, to achieve a solid and resilient reconstruction after the pandemic crisis.

In this plan we can also analyze the digital world and the importance it has on it. One of the main objectives is to promote the digitalization of companies, focusing on SMEs (which account for 25% of the total budget for the digital sector), to strengthen the digital skills of the Spanish population (22%), improve the country's digital connectivity (15%), continue the digitization of public administrations (28%), and support digital-related research and development (R & D) and the deployment of digital technologies (10%).

The plan contains measures to boost digital transformation in industries and companies, with a particular focus on Spanish micro-enterprises and SMEs, to help them make the transition to digitalization of production processes and distribution channels.

To improve the digital skills of the population, the Plan foresees specific measures to promote the digitalization of the education system, ambitious programs to boost the upgrading and retraining of the workforce and specific initiatives to develop advanced digital skills in key technologies such as AI.

The ranges obtained in each of the four areas for Spain can be seen in the following figure:

Illustration 11. Spanish ranking

Image source: Own

Human capital

1 Human capital	Spain		EU
	rank	score	score
DESI 2021	12	48.3	47.1

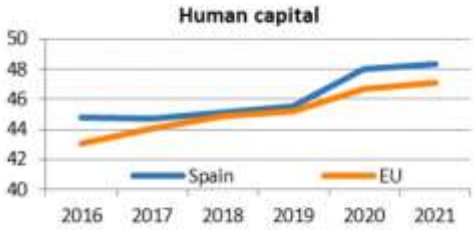

Illustration 12. Human capital in Spain

Image source: *Digital Economy and Society Index (DESI) 2021 Spain*. (2021)

Spain is ranked 12th in this field. 57% of the Spanish population has basic digital skills, but this percentage is far from the target set by Brussels for 2030, which establishes that at least 80% of the population should have basic digital skills.

Moreover, 36% of the working population still lacks basic computer skills, which is a major difficulty in the digitization of enterprises and the uptake of advanced technologies.

The presence of technology professionals is only 3.8%, compared to 4.3% of the EU average and 5.5% in Denmark (leader in the ranking). The arrival of the Next Generation funds (a massive EU recovery fund to support EU member states hit by the COVID-19 pandemic) and the plan approved by the government, Spain Digital 2025, could give a definitive boost to the training of ICT professionals and the digitization of SMEs.

In Digital Spain 2025, one of the ten most important digital strategy priorities is to support the digital skills of the population. There are programs that promote the learning of digital skills to a wide range of the population. For instance, the “Educa en Digital Programme”, launched in June 2020, sets out measures to promote greater digitalization of the Spanish education system, and thus promote greater social inclusion.

Another initiative that provides free cybersecurity training is “Talento Hacker”, launched in April 2021, with the aim of fostering cybersecurity learning across different types of target audiences.

Connectivity

2 Connectivity	Spain		EU
	rank	score	score
DESI 2021	3	62.0	50.2

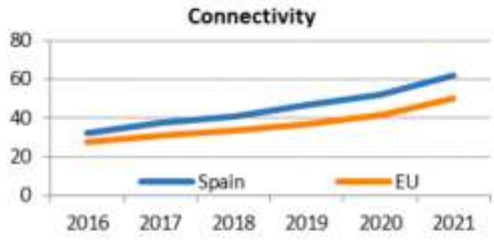

Illustration 13. Connectivity in Spain

Image source: *Digital Economy and Society Index (DESI) 2021 Spain*. (2021)

In this area, Spain is in third place. Despite showing a high performance in connectivity and in the improvement in the implementation of fibre optic networks, the digital divide between rural and urban areas is still quite significant.

To try to remedy this problem, a 5G Technology Promotion Strategy has been presented to accelerate the implementation of these networks, an area where a leap forward is expected with the arrival of the recovery funds. Spain's Roadmap to encourage investment in 5G networks and services contains several measures to reduce the cost of broadband deployment.

In 2020, 92% of Spanish households had very high-capacity fixed network coverage, well above the EU average (59%). However, in rural areas, this percentage is much lower, dropping to 62%.

Integration of Digital Technology

3 Integration of digital technology	Spain		EU
	rank	score	score
DESI 2021	16	38.8	37.6

Illustration 14. Integration of Digital Technology in Spain.

Image source: *Digital Economy and Society Index (DESI) 2021 Spain*. (2021)

Spain is in 16th place. At least 62% of Spanish SMEs have a basic level of digital intensity. Although the figure for those that sell online is 7 points above the EU average, i.e., 24% of them, only 7% sell online in other EU countries.

Brussels stresses that SMEs could make better use of the opportunities offered by new technologies. To this end, the SME Digitalization Plan was created in Spain with the aim of boosting entrepreneurship in the digital sphere and generating a breakthrough in the digital sector to bring about a radical renewal.

It should also be noted that in the Digital Spain 2025 agenda, one of the objectives is to introduce artificial intelligence into value chains and generate an environment of trust around inclusive and sustainable AI. Spain's Recovery, Transformation and Resilience Plan also earmarks significant investments for the digitization of SMEs.

Digital Public Services

4 Digital public services	Spain		EU
	rank	score	score
DESI 2021	7	80.7	68.1

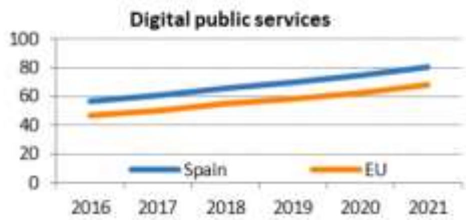

Illustration 15. Digital Public Services in Spain.

Image source: *Digital Economy and Society Index (DESI) 2021 Spain*. (2021)

In this area, Spain is well above average, ranking seventh. There is a high level of online interaction between public authorities, citizens, and businesses.

67% of Spanish internet users actively participate in eGovernment services, due in part to the default digital strategy implemented throughout their central administration.

One of the priorities in Digital Spain 2025 is the digitization of public administrations. To achieve this goal, the Plan for the Digitalization of Public Administrations was published, which aims to make 50% of all digital public services accessible via mobile by the end of 2025.

Current state of the art

When we talk about current state of the art, we refer to existing or current technologies. In Spain, many companies are investing large sums of money in modernizing their companies and updating the way they operate to optimize production processes and improve performance.

The implementation of Industry 4.0, which aims to combine advanced production and operations techniques that will be integrated into organizations, is still in its infancy in European companies. However, Spain leads this transformation, as 29% of Spanish companies have started with the digital transformation in production processes, above the 23% presented by other European countries.

This is the result of a survey conducted by the market research institute YouGov on behalf of the Handelsblatt Research Institute and TeamViewer among 1,452 managers in ten European countries.

The concept of Industry 4.0 for most of the executives surveyed is described as a multidimensional approach to digitizing their companies. For three quarters of the surveyed population, this transformation includes the use of technology and data to achieve digitalization in production processes, focusing on machines, as well as the use of augmented reality (AR) and artificial intelligence (AI) to support the manual processes of workers through digital technology.

Likewise, most of the people surveyed (more than 70%) assured that this transformation will bring better working conditions, as well as more security and a new way of understanding companies.

This survey reveals that the most influential technologies and trends in Spain that will drive digitalization in the future are cybersecurity (27%), digital platforms (25%), the Internet of Things (IoT) (25%) and cloud services (24%). In contrast, Blockchain (12%) and Chatbots (12%) are expected to be less important in this implementation.

Most of the managers who participated in the survey associate the use of innovative technologies in production with an increase in efficiency (82%). Similarly, in terms of the benefits they expect, they mentioned improved quality and service level (81%), cost reduction (81%), enhanced safety, health and security of employees, and security of buildings and information (80%).

In contrast, there are other fields in which digitization is not progressing as planned. This is the case of logistics digitization, as barely 36% of companies, according to a survey conducted by the research institute, have started their digitization. There are green shoots in the national logistics industry since, of that percentage of digitized companies, 43% have completed between 70 and 100% of their transformation process to new technologies.

Conversely, the research also concludes that the time and cost involved (32%) is currently the biggest problem for digitizing the production of companies.

Therefore, considering that Spain is one of the leading countries in digitization and in the change towards 4.0 technology, we will analyze a series of companies that are leaders in Industry 4.0.

Industry 4.0 in some Spanish industrial sectors

In terms of the different Spanish production sectors, the chemical, aeronautics, and transport sectors are some of those in which the level of global and Spanish digital transformation is higher.

- Aeronautics.

If we pay attention to sales and employment data, the Spanish aeronautics sector is in fifth place in Europe. This advantageous position is due to the presence in the country of plants of leading companies in the sector, such as Airbus and Alestis, as well as specialized R&D centers.

According to the data presented in the strategic guide "Challenges of the Aeronautical Sector in Spain", this sector accounts for 6% of spending on technological innovation in the country. In addition, this same guide reflects that for every €100 invested in R&D&I, the Spanish GDP increases by €700. In addition, a percentage of 9.5% of this turnover is reinvested in research and digitization.

- Automotion

Although the automotive sector has changed very little over the years, the advent of digital transformation has brought remarkable changes to this sector. In Europe, only Germany surpasses Spain in vehicle production, so improvements due to digitalization will bring numerous benefits to the country's economy.

Technologies such as Big Data, the Internet of Things and robotics have made a step forward in monitoring processes and thus making them more efficient. Especially the field of robotics, since, according to data from the Spanish Association of Robotics and Automation of Production Technologies, 6 out of 10 robots are found in automotive plants.

- Chemical Industry

Despite the importance of this industry in the country's economy, the level of digitalization is much lower than in the two sectors mentioned above. According to Deloitte, a brand that provides auditing, consulting and advisory services among other services, exposes that the main problem is the lack of a defined strategy for this digital transformation.

To mitigate this effect, plans are being carried out through which issues such as Industry 4.0, Big Data, cybersecurity, or Internet of Things are considered.

The following are some of the Spanish industrial plants that are pioneers in the development of Industry 4.0 and how they are investing to achieve this advance.

1. Schneider Electric.

Schneider Electric is a manufacturer and supplier global energy and automation solutions digital technologies, that offer efficiency and sustainability and has become a great example of a turnaround into a service company. Thanks to the use of the Internet of Things, the cloud, data analysis, an open innovation program and a structured innovation methodology, they have reduced the time to market considerably from 3 years to only 9 months.

The change envisaged by this company to achieve a more electric and digital world may be fundamental to face a climate crisis. To achieve this, they are building a green electricity, since according to some studies, in 2040, twice as much electricity will be needed to meet the needs, this corresponds to 40% of total energy consumption. Moreover, the amount of energy generated by solar and wind power will be multiplied by six.

The company is paving the way to Industry 4.0 with FDM technology or additive manufacturing. As the head of Industrialization and Global Supply Chain Maintenance at Schneider Electric's Puente la Reina plant in Spain says, "Not only can we efficiently produce our manufacturing tools in-house, but now also thanks to FDM technology we have the ability to design the tools we need in the exact shape, size and quantity required."

Therefore, taking advantage of the heyday of Industry 4. 0, Schneider Electric has embarked on a project with a large-scale implementation process: the “Smart Factory” project. This strategy aims to increase production efficiency by reducing costs. Since the beginning of this project, additive manufacturing has played a key role in achieving this goal.

The plant of this company located in Navarre, Spain, is a magnificent example of the implementation of this project. It employs people specialized in the manufacture and assembly of electrical appliances and equipment, such as light switches or sockets. After testing several 3D printing technologies, it was decided that it was better to invest in FDM technology as it provided a more reliable and repeatable production method for 3D printing a range of tools.

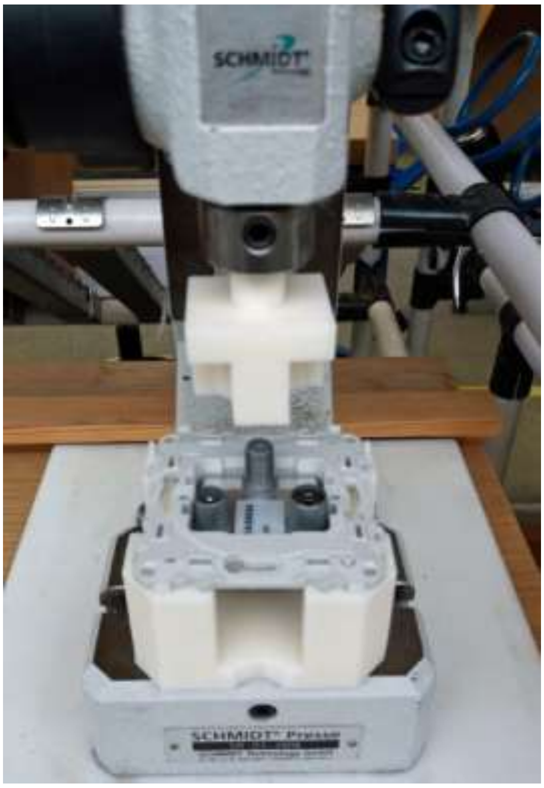

Illustration 16. Example of FDM technology

Image source: *SchneiderElectric - ES FDM Case Study*. (2021). Schneider Electric.

Schneider Electric uses the Stratasys F170TM Printing Machine, an industry-grade, cost-effective FDM 3D printer. It uses a wide range of available engineering-grade thermoplastics that are ideal for both design and production applications. The 3D printer, which was launched immediately, has become a real production machine in the factory.

The cost savings can also be seen in the replacement of aluminum parts by alternative 3D printed parts, as it is normal for aluminum parts to break if they collide, resulting in replacement being very expensive.

2. Ford

The Ford factory in Valencia is at a very advanced stage in the implementation of Industry 4. 0. The brand will implement and validate its manufacturing processes with the latest 5G technology and innovations in mobile robotics, virtual reality, and artificial intelligence.

The transformation of the plant is expected to be carried out over three years, supported by the "5G-INDUCE" project. This initiative is included in the European Commission's infrastructure plan to offer innovative 5G solutions.

The implementation of 5G and new technologies is expected to increase the capacity for innovation, a key factor in today's competitive environment. Some of the ways in which Industry 4.0 can be implemented and the technologies involved will be explained below.

- Flexible manufacturing.

More than 2,000 robots are distributed throughout the factory. These robots can handle the heaviest or most expensive jobs, such as painting cars, but they can also work side by side with the workers on a wide range of tasks, such as checking any part of the car.

Ford's automotive plant in Valencia stands out for implementing one of the proposals of Industry 4.0, flexible manufacturing. The change lies in the fact that its production lines have been united into one, and all models go through it. In other words, it is now the machines that adapt to the manufacturing process, and not the other way around, as in the past. For example, when you want to paint a car, a machine reads the car's label by means of Artificial Intelligence and adapts to the relevant requirements.

To have a more accurate review, wearables have been added. Until now, workers had to go to desktop computers to access the necessary information. Now, a simple mobile application makes it possible for quality and specification tests to be carried out 'in situ', via a wearable quality assurance device. This has resulted in reduced manufacturing times for each vehicle and a reduction in human error.

- Autonomous management

Automated guided vehicles (AGV) are also employed, although only for some indoor functions, with magnetic line-guided units. A small fleet of automated guided vehicles with simultaneous location and mapping (SLAM) navigation will address these needs through 5G connectivity and edge computing capabilities.

- Intelligent operations thanks to gesture recognition.

The goal is to get to control AGVs by gestures, without the need to use other equipment, such as special gloves or augmented reality glasses.

With this intelligent monitoring, safety will gain and so will the operator, who will not need to carry special equipment or spend extra time on it. Likewise, there is no need to spend additional money on equipment, as no special features are necessary.

- Immersion in virtual reality

Through immersion thanks to virtual reality, the operator can have an interactive and high-quality view of what is always happening in the automatically guided vehicles. In addition, thanks to this technology, the plant will have other advantages, such as an increase in the security of the facilities or the recognition of the people who work there to prevent intruders or people from entering restricted areas.

The goal of this part of the project will be to explore the capabilities of combining virtual reality and next generation 5G technology to give a remote viewer an immersive, live 360° view from the AGV.

3. “Tableros Tradema”

It seems hard to imagine that a company dedicated to the manufacture of wood panels would become an example in Spain of Industry 4.0, adapting a model that its owner wants to replicate in each of its factories around the world. That is what is happening with the factory that Sonae Arauco has in Valladolid, a true pioneer in our country of digitization and Big Data.

The company has managed to reduce product failures at its Valladolid plant with the help of Artificial Intelligence-based assistants that help operators make better decisions, better control the process and anticipate possible failures. As a result, the entire manufacturing process is controlled in real time from its control room.

The process is carried out with the interconnection of all the machines involved in the process and thanks to the use of Big Data and Artificial Intelligence techniques the company generates models that allow predicting the behavior of the product.

With predictive manufacturing and maintenance, you can not only save raw material but also anticipate possible breakdowns. The connection between machines, data and people is such that a smartwatch can simultaneously control the activity of factories located in different countries.

4. Sesderma.

This Valencian cosmetics company has managed to increase its manufacturing by 25% without additional investment, while reducing direct labor costs by up to 20%.

To achieve these figures, the company has followed the machine learning method, applied by the Valencian startup Mesbook. By means of predefined rules, the technology obtains the relevant information to present conclusions that allow factory managers to make the right decisions at the right time and in an objective manner.

The sensors are linked to the planning systems and collect and store information for later use. The machines are connected to each other and to the company's system. The result of this connectivity is an increase in productivity, reducing labor and production costs.

These data are analyzed in real time since the indicators appear directly on Sesderma's plant controllers without having to allocate resources to this. As for incidents, it not only detects them, but also allows them to be quantified.

5. IML Solutions

This company based in Ibi, Alicante, is committed to predictive maintenance, i.e., detecting possible faults and defects in machinery before they occur. This company has two main divisions: mold manufacturing and robotics.

Illustration 17. Technology example at IML Solutions

Image source: Biot, R., & Climent, M. (2017, January 30). *Quién lidera en España la carrera de la Industria 4.0*. ELMUNDO.

The part dedicated to the manufacture of molds could be improved by applying intelligence to the process, through sensors in the injection molds and automated analysis systems, thus being able to know in real time the behavior of the mold. This is very valuable information for the customer, since the moment when a mold is going to break is known thanks to artificial intelligence and the Big Data system.

6. Volkswagen

The Volkswagen plant located in Navarra has taken several steps towards Industry 4.0. In 2015, it won first place in the Volkswagen Innovation Awards thanks to an application based on augmented reality, developed together with a Navarre startup called iAR. This technology provided information about a car's infrastructure through virtual tags that were read by tablets.

Another breakthrough was the incorporation of virtual reality glasses to train its staff in the Volkswagen Polo. Thanks to these glasses, it is possible to see the car inside and out, as well as simulate actions such as starting the engine or turning on the radio.

The latest innovation of this company at its headquarters in Navarra has been an artificial vision tunnel with the latest technology. This tunnel is in the paint shop and makes it possible to detect any imperfection in the bodywork. This installation, a pioneer within the Volkswagen brand, uses the images obtained by 30 cameras and the lighting of 300,000 LEDs distributed in four arches.

Illustration 18. Artificial vision tunnel of Volkswagen

Image source: *pone en marcha un túnel de visión artificial con la última tecnología*. (2018, March 7). Volkswagen Navarra.

Using powerful mathematical algorithms, the computer searches images for possible imperfections in light reflection. It can detect even the smallest imperfection, such as a footprint or a drop of water, and the location of the imperfection to reduce detection time and visual fatigue.

7. Alstom

Alstom is a corporation focused on the business of electricity generation, as well as the manufacture of trains and ships. The headquarters of this company in Barcelona stands out for being the first factory 4.0 of the railway sector in Spain and for being the most modern of the group in Europe.

This commitment will advance in the application of intelligent systems in production processes, based on 3D design, additive manufacturing, robotics, artificial intelligence, and augmented reality.

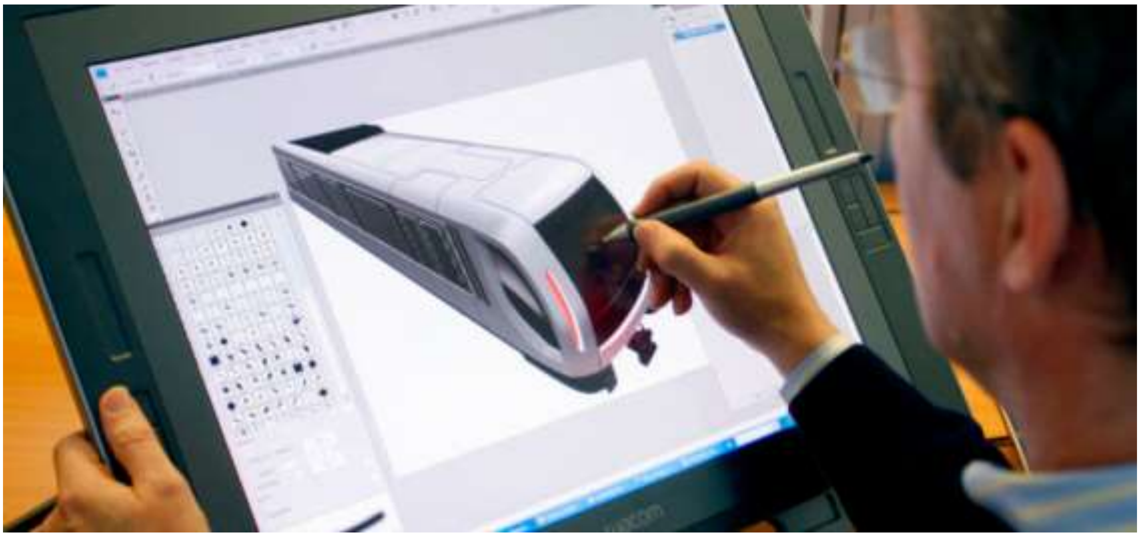

Illustration 19. Example of Alstom.

Image source: Alstom España desarrollará la primera Fábrica 4.0 del sector ferroviario en España. (2016). Interempresas.

As part of its commitment to Industry 4.0, Alstom has also announced that it will make available to its suppliers a park of up to 30,000 square meters of new warehouses in an integration that seeks to streamline processes and facilitate the work between supplier and manufacturer.

8. Airbus

The aeronautical company has increased its presence in Spain to develop new hydrogen technologies. Airbus has unveiled in Spain the launch of the "Airbus UpNext" entity and a "Zero Emissions Development Center (ZEDC)".

Airbus UpNext enables the latest technologies to be developed faster through the construction of high-speed, large-scale demonstrators. This will encourage the search for new talent and suppliers to evaluate, mature and validate potential innovative products and services that encompass major technological breakthroughs.

The focus of the Spanish ZEDC is non-propulsive power, fuel cell cooling systems and fiber optics. These technologies are essential to power a future zero-emission aircraft to achieve entry into service by 2035.

Barriers to I4.0 and benefits of I4.0 in Spain

The immersion of digital technologies inside factories implies a transformation and a considerable change in the current production processes. The implementation of Industry 4.0 strategies has generated numerous benefits for companies and organizations, but there are also some negative aspects to be mentioned.

The main benefits that can be mentioned about this implementation are:

- Generation of new types of jobs and businesses, even in the most traditional sectors.
- Thanks to the use of artificial intelligence, the autonomous operation of the devices is achieved, thus reducing operational costs.
- The integration of activities in real time provides high-speed data processing, allowing remote monitoring of most of the processes, thus achieving greater control and transparency when accessing information.
- Sustainability is increased: using detection sensors that interrupt activity when they detect an idle moment, or devices that work with renewable energy.
- Increased process safety. This is especially important for work at high temperatures, with heavy weights or in hazardous environments.
- It increases the quality level of both processes and products, since automation allows greater precision in weights, measures, and mixtures. Human involvement in the processes is reduced, thus decreasing operational errors.
- A much more flexible production can be realized since the product can be customized to the requirements of each company.
- Automation ensures much more accurate and agile operations.
- Thanks to communication networks, reaction and decision-making times are reduced, as the flow of data is much more efficient.
- Finally, if higher quality products can be offered, a better response is given to market needs, reacting more quickly and efficiently to market changes. This leads to greater business competitiveness.

Despite the obvious benefits that the implementation of Industry 4.0 brings with it, we are talking about a change of great magnitude and therefore it is logical that it must overcome obstacles to achieve its implementation and maturity.

In a study conducted by Pwc, in which respondents were asked about the main barriers that hinder the implementation of digital processes, the following results were obtained:

- Lack of training and digital culture (76%).
- Lack of knowledge about the economic benefits of this transformation (56%).
- Lack of leadership (64%).
- High cost (28%).
- Lack of collaboration from partners (24%).
- Shortage of talent (20%).

One of the biggest barriers is the lack of precise knowledge regarding the potential of these technologies, and consequently the strategic importance that they can have for the medium/long term future of companies. An analysis of the direct impact of these technologies on the reality of each organization is needed, as well as roadmaps to guide technological progress so that the issue takes on the necessary importance.

Another disadvantage to make these processes effective is that it requires qualified personnel. The lack of training of people and even managers of a company in new technologies is notorious. It is necessary to train the new generations to try to eliminate this technological barrier.

This change implies and will imply conflicts between workers due to both the new work environment and the resistance of people to adopt these technologies. A clear, strategic, and people-centered response is needed, with special attention to avoiding tensions in the labor market.

Another aspect that is particularly complicated is taking advantage of the possibilities offered by technologies, due to the limited level of standardization and integration of manufacturing processes and work systems. It should also be considered that most of the major technologies have been developed by or for companies, which means that research is needed in this field.

In terms of capital investment, there is a need to increase multi-year investments by approximately 50% over the next five years. From an organizational and management point of view, there are clear challenges in the integration of the value chain, different processes, and departments in the companies.

The new interconnected systems require significant efforts to improve security, as they are also easier to access. For this reason, it is essential to increase the level of knowledge about cybersecurity and improve it to offer greater security to the population.

Finally, the speed at which this development is taking place can be considered a drawback, and updating the solutions provided to the problems may result in several companies becoming outdated.

Contemplating all the advantages and barriers presented by Industry 4.0 and considering the current state of Spain in terms of implementation of new technologies, it can be concluded that although the state of evolution is very positive, there are still barriers to overcome to achieve a fully effective implementation of technologies in companies and in everyday life.

Industry 4.0 in Italy

Incorporation of Industry 4.0 in Italy

As in Spain, Industry 4.0 has been at the center of the economic transformation in Italy in recent years. In 2016, an ad hoc government plan was launched in the country, which, has been undergoing evolutions and revisions since that year: from the industry 4.0 Plan to the national plan of the Transition 4.0.

The situation resulting from the healthcare crisis has led to the growth of investment in digitization. Large companies are reportedly looking to strengthen the supply chain ecosystem while SMEs are looking to modernize.

With the help of several studies, the newspaper “Italia Oggi”, has concluded that the level of digitalization in Italy is quite heterogeneous, being much higher in the regional areas most affected by the pandemic and less so in rural areas. The provinces with the most digital and efficient infrastructures are Milano, Genova, and Rome. Whereas territories such as Molise, Abruzzo and Marche are the furthest behind in this digitization.

With which, it can be confirmed that the Italian Industry 4.0 is in a great moment of growth regarding experimentation and application activities in the field. "L'Osservatorio Transizione Industria 4.0" is the reference point in Italy for managers and decision makers who need to understand in depth the digital innovations that are transforming the manufacturing sector, codifying, and making knowledge available.

The technologies that are being most influential in the transformation of Italian companies are undoubtedly I-IoT and Industrial Analytics (they constitute about 40% of the declared applications); these two technologies materialize in the three macro-application areas (Smart Factory, Smart Supply Chain and Smart Lifecycle).

- The Smart Factory process area is confirmed as the most mature, accounting for 46% of the applications reported by respondents. On the other hand, Industrial Analytics, Advanced HMI, and Advanced Automation have a much lower adoption rate of 35%.

- The Intelligent Supply Chain area is further behind; the use of cloud platforms has increased by 40% compared to last year, but the current usage rate is 18%, still very low. The Analytics world has a very high adoption rate at 27%.

- In the field of Smart Lifecycle, Additive Manufacturing confirms its prominence in the prototyping phases (with an adoption rate of 22%), it is the I-IoT, Analytics and Advanced HMI applications that have grown the most in the last 12 months. The adoption rate of these applications has increased the most over the last 12 months, settling at values above 20%.

These are the data presented by "L'Osservatorio Transizione Industria 4.0" at the end of 2021 to understand the evolution in companies of the technology and to see in which areas this development is mostly taking place.

Laws for digitalization.

The Italian government has carried out a series of plans and reforms to boost the implementation of digitalization both in companies and in everyday life.

After repeated announcements, on September 21, 2016, the then Minister of Economic Development and the then Prime Minister presented the Government Plan for Industry 4.0, which is contained within the Budget Law 2017, which was approved in December 2016.

This first plan arose from the need to mobilize private investments in 2017 with a focus on technologies and presented an opportunity for companies to take advantage of the benefits linked to the fourth industrial revolution.

At its inception, this Plan had envisaged a series of measures (these measures were later partially modified):

1. Hyper and Super Depreciation: The objective sought by this measure is to encourage and support companies to invest in new capital goods, which help the technological and digital transformation of production processes. Hyper amortization is based on the 250% overvaluation of all investments in new devices or key technologies for the rise of Industry 4.0. Super-depreciation, on the other hand, provides for a 140% overvaluation of investments in assets, whether purchased or leased.

2. "Nuova Sabatini": Its objective is to support companies that need bank loans for investments in new capital goods, such as machinery, plant, or factory equipment.

3. R&D Tax Credit: The objective is to stimulate private spending on R&D to innovate processes and products and thus ensure the future competitiveness of companies.

4. Patent Pool: Consists of an optional regime of subsidized taxation on income derived from the use of intangible assets, whether industrial patents, trademarks, industrial designs, know-how or copyrighted software.

5. Startups and innovative SMEs: New innovative companies (startups) enjoy a framework of reference dedicated to them in matters such as administrative simplification, labor market, tax advantages, bankruptcy law. Most of the measures are also extended to small and medium-sized companies that focus on the field of technological research and innovation, these companies are known as innovative SMEs.

6. Guarantee Fund: this clause consisted of supporting both companies and professionals who cannot access credit or have difficulties in doing so. It consists of granting a public guarantee, up to a maximum of 80% of the loan, for both short and medium-long term operations, both to cover liquidity needs and to make investments.

The industry 4.0 plan promoted the creation of the Centers of Competence, whose main mission is to train companies and carry out orientation activities, to offer support in the realization of innovation-related projects, aimed at the development and creation of new processes or products through Industry 4.0 technologies.

There are eight centers of excellence for Industry 4.0 spread throughout Italy (Milan, Turin, Bologna, Genoa, Padua, Pisa, Rome and Naples), which are linked to more than 50 universities and about 400 companies.

In 2017, an initial balance sheet was drawn up on the results brought about by this plan. In this balance sheet, it was exposed that the number of companies investing in Research and Development increased; orders in the domestic market for capital goods increased; and the Guarantee Fund increased significantly (10.7%).

Thus, it was concluded that the industry 4.0 Plan had a positive impact on Italian production, as companies started to invest in technology again after a period of inactivity in this field. For this reason, Research 2016-2017 is considered "the great opportunity for development and innovation".

In September 2017, the second phase of the National Plan was presented, the program changed its name to “Empresa 4.0”. The intention of this reform in the national Industry 4.0 plan was to give importance to the service sector. The transition to the “Empresa 4.0” took place in 2018 with a remodeling being carried out in this one.

What was intended to be seen in this reform was a change of paradigm aimed, no longer at large companies, but to favor small and medium-sized companies. Some novelties in this plan with respect to the previous one are:

- The super amortization has not been extended, as a compensation to this suppression, the mini IRES appeared for companies that invest in new plants or hire more personnel.

- The hyper amortization has been reformulated with the aim of helping SMEs.

- The amount of tax credit earmarked for research and development is reduced.

- The "New Sabini" is refinanced.

However, despite all these reforms aimed at increasing digitalization in Italy, the EY 2019 Manufacturing Maturity Index survey reveals that only 14% of Italian companies have reached an advanced state of digital development characterized by evolved 4.0 planning. By the latter term we mean systems that are capable of transporting and exchanging information efficiently.

Forty-nine percent are already laying the foundations for digital process management and more than a third of the companies (37%) are at an early stage and are undergoing a digital transformation. The survey shows that a small proportion of companies, only 5%, have a fully structured and automated system for data integration.

The survey also reveals that there is a gap between large and small companies, as most large companies have innovative technologies in place, thus taking advantage of the tax benefits linked to investment in innovation.

Despite EY's far from comforting estimates, the industry 4.0 market in Italy in the pre-coronavirus era, i.e., in 2019, reached a value of €3.9 billion, up 22% on the previous year. As the "Industry 4.0 Observatory" of the Politecnico di Milano School of Management points out, this sector has practically tripled in four years.

Subsequently, and with the need to extend and facilitate the use of the national 4.0 transition plan, the government promoted the 4.0 Transition Plan. Italy's National

Transition 4.0 Plan has as its main objective to support and incentivize Italian companies to invest in new technologically advanced interconnected capital goods through a tax credit mechanism.

A McKinsey study published in February 2021, entitled "COVID-19: A Turning Point for Industry 4.0", reveals that the approach of some companies or organizations has influenced their response to the pandemic. The three main conclusions were as follows: companies that had already scaled digital technologies came out of the crisis stronger; those that were still implementing these solutions were able to test them in reality; while in those companies where digitization had not yet taken place, this crisis was a wake-up call.

Digital Economy and Society Index in Italy

As was done in the case of Spain, the Digital Economy and Society Index (DESI) for Italy will be analyzed. As previously mentioned, this index measures, on a scale from 0 to 100, the progress of the European Union as well as of the individual Member States with respect to the main thematic areas of global policy.

For the 2021 edition, Italy is overall ranked 20th among the 27 European Union member states, five positions higher than in the 2020 report.

	Italy		EU
	rank	score	score
DESI 2021	20	45.5	50.7

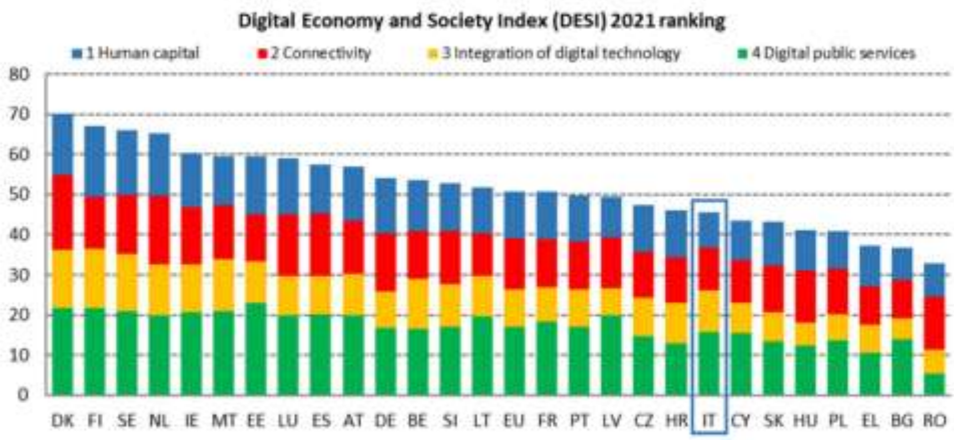

Illustration 20. Italy's DESI ranking.

Image source: Digital Economy and Society Index (DESI) 2021 Italy. (2021)

During 2020, Italy made numerous advances in issues related to the uptake of connectivity networks, especially those that can offer speeds of up to 1 Gbps. Despite this progress, the pace of fiber deployment slowed compared to the previous year and much progress and effort is still needed to achieve effective and reliable very high-capacity network coverage.

In terms of human capital, Italy has low levels of both basic and advanced digital skills, lagging far behind other EU countries in this area.

The number of Italian online users using e-government increased by 6% (from 30% in 2020 to 36% in 2021), but this is still below the EU average. Inequality is observed between regions in terms of the use of electronic health records by healthcare staff and individuals.

On a very positive note, 69% of small and medium-sized companies have a basic level of digital integration, compared to the European average of 60%. Italian companies have effectively developed the use of electronic invoices, however, there is a lack of information on the use of key Industry 4.0 technologies, such as artificial intelligence and big data.

The last two years have seen an acceleration in the adoption of digital public service enabling platforms. It is expected that with the new reforms in the National Recovery and Resilience Plan, a boost will be given to the modernization and digitization of the country's public services.

To reduce some of the gaps that may exist in digital skills, Italy launched in 2020 a "National Digital Skills strategy" as well as a plan with specific actions to achieve ambitious digitization targets.

To close the gap between Italy and other EU countries and overcome the lags in some technological area, sustained efforts, and an integrated approach to policies on connectivity, human capital, innovation, and competitiveness among enterprises are needed. A good implementation of the initiatives undertaken in recent years can boost the digitalization of the country and provide the much-desired opportunity for change.

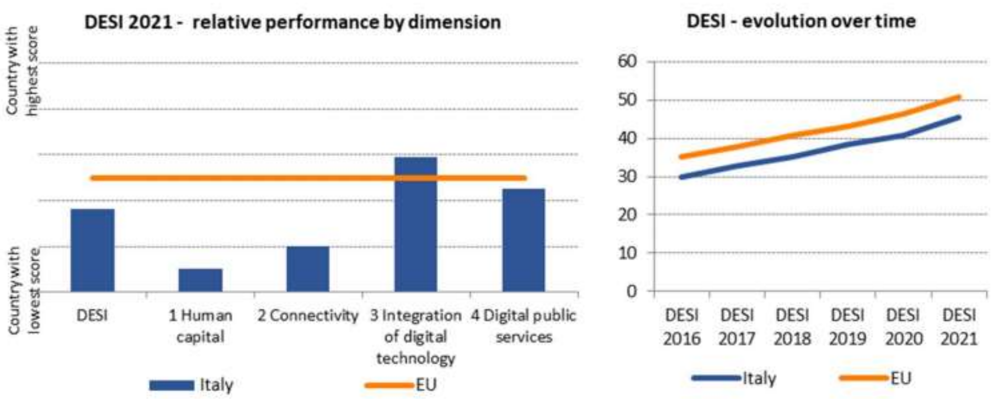

Illustration 21. Relative performance by dimension and evolution over time in Italy

Image source: Digital Economy and Society Index (DESI) 2021 Italy. (2021)

The ranges obtained in each of the four areas for Italy can be seen in the following figure:

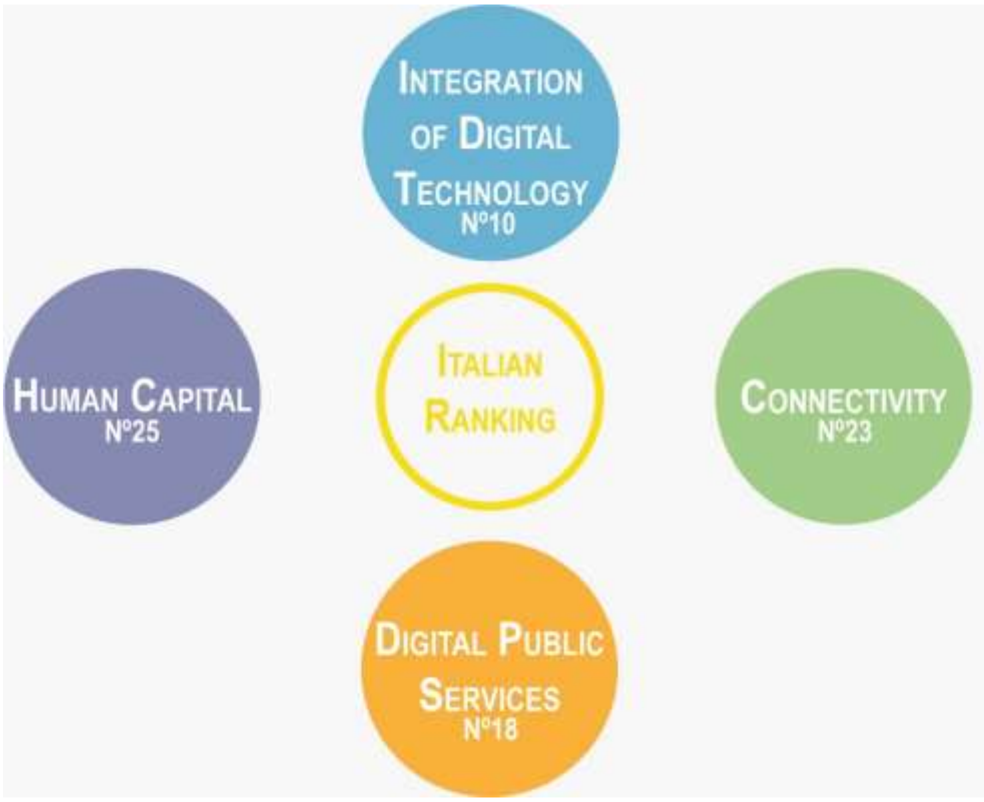

Illustration 22. Italian Ranking

Image source: Own

Human capital.

1 Human capital	Italy		EU
	rank	score	score
DESI 2021	25	35.1	47.1

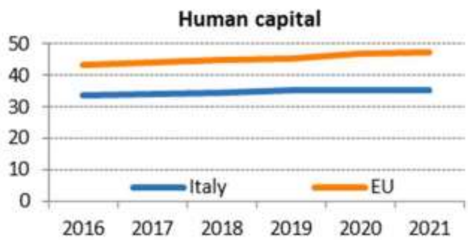

Illustration 23. Human Capital in Italy

Image source: Digital Economy and Society Index (DESI) 2021 Italy. (2021)

As can be seen in the figure above, Italy ranks 25th in terms of human capital. In Italy, only 22% of the population has knowledge of advanced digital skills, compared to a European average of 31%. Moreover, in the 16-74 age range, only 42% of people possess at least basic digitalization skills (56% in the EU).

Only 1.3% of Italian graduates have studied ICT, making the percentage of specialists in this field only 3.6% of the country's total employment. As far as female ICT specialists are concerned, the percentage is closer to the European average, with 16% female representation in this field compared to the EU average of 19%.

In 2020, Italy launched a National Digital Skills Strategy, which aimed to increase its digital skills to reduce the existing gap with other EU countries.

It has four key points, covering a large target group and a wide range of areas:

- Encourage e-skills learning from primary education to university or higher education clicks.
- ICT specialists to have the opportunity to open new markets and create new types of jobs.
- Activate the workforce and the market based on advanced, basic, or specialized digital skills.
- This strategy is also aimed at the public, so that citizens can develop digital skills.

In conclusion, Italy must improve digital skills, both basic and advanced, as this backwardness may be reflected soon in the digital exclusion of a significant part of the population and reduce the possibilities of companies to innovate. The National Digital Skills Strategy has been an attempt to reduce the gap. It is essential to focus on education and training of people in this field, to increase professionals and knowledge in society.

Connectivity

2 Connectivity	Italy		EU
	rank	score	score
DESI 2021	23	42.4	50.2

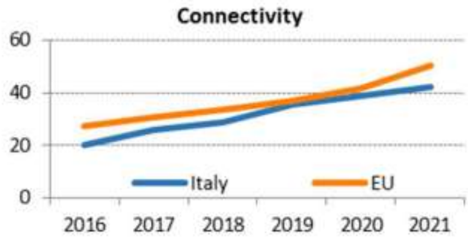

Illustration 24. Connectivity in Italy

Image source: Digital Economy and Society Index (DESI) 2021 Italy. (2021)

In terms of connectivity, Italy ranks 23rd among European Union countries. The number of households with fixed broadband is 61%, which is slightly below the European average of 77%. The percentage of households with at least 100 Mbps has grown in recent years to 28%, however, this percentage is below the European average (34%).

The number of households with at least 1 Gbps has increased significantly since 2019, placing this value well above the European average. In terms of next-generation fast broadband access, the number of households included is 93%, above the 87% EU average.

The percentage of households covered with very high-capacity network coverage was 34%, considerably lower than the EU average (59%). FTTP coverage stood at 33.7% of households (up from 30% in 2019), increasing at almost the same rate as the EU average (42.5% in 2020, up from 37.5% the previous year).

Even though the country has a fairly high score in 5G readiness (60%), only 8% of the areas are covered by 5G technology. The broadband price index is higher than average at 74.

There are plans that encourage connectivity and technology learning in schools. This is the case of the "School Plan", which provides connectivity of up to 1 Gbps for schools and educational institutions, thus connecting the centers.

The national ultra-broadband plan aims not only to meet but to exceed the targets set by the European Commission for 2030; to achieve this, it aims to introduce at least 1 Gbps for all by 2026. This plan foresees that when private fixed and wireless networks cannot continue to finance this target, the State can act by creating the necessary infrastructures to achieve it.

The pandemic stimulated the acceleration of ultra-broadband coverage in many areas. However, much more structural solutions are needed to address the remaining delays in the rollout of Italy's ultra-broadband plan. It is important to translate Italy's high score in relation to 5G readiness into good 5G coverage in populated areas, for this, it will be necessary implement measures to achieve efficient 5G connectivity and continue with all structural reforms.

Integration of digital technology.

3 Integration of digital technology	Italy		EU
	rank	score	score
DESI 2021	10	41.4	37.6

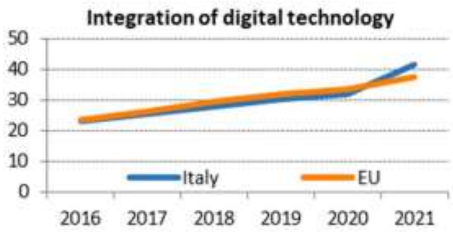

Illustration 25. Integration of digital technology in Italy.

Image source: Digital Economy and Society Index (DESI) 2021 Italy. (2021)

Italy ranks tenth in integration of digital technology. A large proportion of Italian SMEs, 69%, have at least a basic level of digital intensity, which is well above the European average of 60%. Italian companies also score very positively in terms of the use of electronic invoices; more than 90% of companies use them (three times the European average in this area). The proportion of companies making use of cloud services increased from 15% in 2018 to 38% in 2020.

However, there are other areas with a much lower performance. The use of technologies based on artificial intelligence is 7 points below the European average; the use of big data is low, with only 9% of Italian companies implementing it.

In the field of advanced digital technologies, Italy has been involved in several European initiatives. In early 2021, it launched a call for interest for "Important Projects of Common European Interest" dealing with cloud services or infrastructures for the next generations. It is also expected to boost and support projects related to data protection, cybersecurity or healthcare.

Building momentum in the digital economy requires a coordinated and comprehensive approach that combines investment incentives, support services and awareness that links to investments in human capital. It is also critical to train people with digital skills, thereby creating opportunities for young people and high-quality jobs.

Digital public services.

4 Digital public services	Italy		EU
	rank	score	score
DESI 2021	18	63.2	68.1

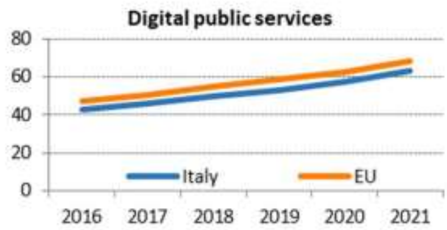

Illustration 26. Digital public services in Italy.

Image source: Digital Economy and Society Index (DESI) 2021 Italy. (2021)

In this area, Italy ranks 18th. The use of digital services is still very low, despite the great improvement recorded. Although the number of Italian users who have turned to eGovernment has increased by 6% from 2019 to 2020, this value is still well below the EU average of 64%. Italy exceeds the EU average in the supply of digital public services for businesses and open data but does not exceed it in the share of digital public services for citizens.

Current state of the art

The scientific director of the "Osservatorio Transizione Industria 4.0" states that the development of Industry 4.0 is not a passing trend but a project that is constantly renewing the Italian industrial sector. The National Plan for Transition 4.0 offers numerous advantages, which are known to manufacturing companies: 83% of the 175 large companies and SMEs interviewed by the Observatory are aware of the tax credit for investments in capital goods, 55% of those for research, development, and innovation and 52% of those for training.

Smart Working spread during the pandemic to manufacturing companies. 37% of companies have introduced forms of flexibility in working time management, another 37% in task and job management, a fifth in shift management, 28% use skills tracking tools, 19% monitor workers' health conditions and 17% leave free choices between working in person or remotely.

Teleworked 40% of training, quality control and plant audit and monitoring activities, and 25-30% of maintenance, workshop management and machine testing activities. And the benefits were clear: flexibility (in 67% of cases) and punctuality (55%) increased and improved response to problems and worker satisfaction (60%) and work-life balance (62%), although in some cases stress and workload increased (16%).

Smart technologies have played a decisive role in enabling this transformation, with companies primarily using tools such as IoT for process mapping (38%), digital dashboards (34%), remote collaboration platforms (25%) and cybersecurity technologies (22%).

However, from an organizational point of view, most companies feel the need to increase the autonomy (31 %) and versatility of workers (29 %) and to involve them more in the digitalization of production processes (29 %), as well as developing their technical, managerial, and decision-making skills.

As far as sustainability is concerned, manufacturing companies are increasingly aware of the competitive advantage that a strong commitment to sustainability can offer. Fifteen percent have already completed sustainability projects in operations, around one third have activated one, and only 3% are not interested. 43% did so to anticipate market trends and respond to customer requests, more than a third to build a sustainable brand image.

A survey addressed to companies with facilities in Italy, whose experience in adopting Industry 4.0 can be considered particularly relevant, shows the following results regarding the frequency of adoption of new technologies.

Industry 4.0 technologies	*Frequency of adoption*
Big data analytics	62.2
Digital supply chain	78.0
Internet of Things	76.8
Cloud computing	79.3
Robotics	75.6
3D printing	41.5
AGV –automated guided vehicles	50.0

Illustration 27. Frequency of adoption of new technologies in Italy.

Image source: Catholic University of the Sacred Heart, Milan - ITALY, University of Ferrara, Ferrara - ITALY, Bocconi University and SDA Bocconi School of Management, Milan - ITALY, Belvedere, V., Chiarini, A., & Grando, A. (2018). *The synergic effect of Industry 4.0 technologies on the operations performance. Evidence from Italy.*

Except for 3D printers, which were adopted by just 41.5 percent of the organizations, the findings of this study show that most selected enterprises are investing or have already invested in the technologies indicated in the questionnaire. "Cloud computing" (79.3%), "Digital supply chain" (78.0%), and "Internet of Things" (78.0%) all have the greatest adoption rates (76.8 percent).

Industry 4.0 in some Italian industrial sectors

Industrial districts have been a fundamental base of the Italian economy, helping the socio-economic development of the country since the 1970s. The number of industrial districts in Italy amounts to 200, representing approximately 38% of the GDP and 40% of the labor force.

Thus, the IDs represent a complex and relevant event as far as the industrial organization of companies is concerned. The growing interest in agglomerations of firms has launched numerous streams of research, on the topics of ID, clusters (concentration of firms in each geographical area or the concentration of different organizations sharing a subject matter and present in a state or region) and clustering processes.

ID with be defined as a socio-territorial entity defined by the active presence of a community of people and a population of businesses in a naturally and historically defined territory. The main elements are a local productive network composed of a set of enterprises and a "favorable industrial environment".

They are characterized by a division of labor among local businesses around a sector that is specialized, which produces external economies and more efficient exchanges. Other major actors, such as municipal authorities, training organizations, business groups, and technology centers, affect IDs by giving resources in terms of financial, normative, and technical assistance.

A growing body of study on IDs has focused on the processes that lead to mature phases and thereafter decline. ID scholars have detected two interrelated patterns: first, an opening of the ID to subsequently lead to an increase in innovation.

Numerous contributions highlight a gradual opening of the identification system as companies create technological and commercial linkages outside the local identification itself. This has resulted in a reorganization of local contacts, which are then coupled with new emergent collaborations with other companies and organizations, many of which are based in different IDs. This strategy has primarily been undertaken by major corporations, who have demonstrated more strategic autonomy. One of the results has been a weakening of social relationships and a reduction in the involvement of essential players such as institutions and business organizations.

One of the most relevant advantages of the IDs is their capacity to encourage the establishment of new knowledge and promote local knowledge mechanisms. As a result, IDs may be viewed since cognitive laboratories or systems, as they are associated with high density of information collection, elaboration, and circulation via multiple transfer mechanisms. It can also be argued that spatial proximity in networks facilitates knowledge sharing, leading to innovation in clusters.

Although geographic proximity is a relevant aspect, it is not enough in itself to understand all the innovation that takes place in local industrial networks. This is because, even if they belong to the same cluster, these companies may have a different degree of access to knowledge, as it depends not only on spatial proximity but also on other factors such as institutions or organizations.

Depending on whether information is tacit or formalized, interactive learning processes in IDs and clusters are arranged in various ways. There is a distinction drawn between "local buzz" and "global pipelines". The "global pipelines" refers to the degree of awareness achieved by investing in building and improving communication channels for suppliers outside the local environment, while the "local buzz" refers to the processes that take place between stakeholders in a community simply because they are there.

The learning mechanisms and processes are based on a mix of informal (emergent knowledge) and formal structures (deliberate structures). Emerging or informal structures are those that are triggered accidentally through networking and personal relationships, whereas purposeful or formal structures are those that are designed, such as R&D collaborations with far-flung partners.

Knowledge sharing in clusters and IDs is focused on "gatekeepers", given their ability to “access external knowledge and construct a conversion process which deciphers external knowledge and turns it into something locally understandable and useful”. El papel que desarrollan como intermediarios se basa en la búsqueda, absorción y combinación de fuentes de conocimiento tanto internas como externas para posteriormente difundir el conocimiento resultante.

While the role of gatekeepers can be developed by leading cluster companies that introduce the most complex innovations and influence decision making, local institutions and knowledge providers support the companies of a DI by providing innovation opportunities and knowledge storage. Some examples of key knowledge providers can be universities, as they are a great source of specialized and up-to-date knowledge.

Increasing digitization has challenged the bicotomy between the local buzz and the global pipeline, since thanks to internet applications it has started to look like buzz in distant areas, i.e., a buzz has appeared without being there.

Having analyzed the main characteristics of industrial districts and the main advantages, a study is now going to be carried out on the process of knowledge diffusion related to Industry 4.0 within an industrial cluster located in central Italy, Pesaro ID, which is specialized in machinery for furniture and wood. This cluster has been considered suitable for the study as it has a specialization in a traditional industrial sector and presents ongoing projects related to I4.0.

Data sources are open-ended interviews and "knowledge dissemination initiatives". Workshops and conferences, training courses, R&D projects, non-research business collaborations, industrial PhD scholarships, and public tenders are six types of dissemination activities that have evolved.

The growth of the Pesaro district reflects quite well the traditional concept of ID, as it derives from the proximity of companies both in the same and adjacent sectors, which begin to build a network of relationships.

Within the industrial district of Pesaro, we can identify some of the leading companies, which represent a focal point for all districts in terms of innovation and growth. In the mechatronics sector we can consider Biesse; IMAB and Scavolini for the furniture sector. Although in 2014-2015 the ID introduced a first phase of digitization projects, the digital shift was mainly driven by investment in infrastructure by local leading companies, while SMEs have started to follow suit by implementing digital projects.

We can distinguish three phases or trajectories of diffusion and dissemination of Industry 4.0 knowledge.

- Pioneer phase.

Between 2015 and 2016, thanks to the efforts of local pioneers, mostly large companies or universities, the concept of Industry 4.0 was introduced for the first time. Biesse has begun to explore I4.0 with one of its main consulting partners, Accenture, which has previously worked on other innovative initiatives. Indeed, before collaborating with Biesse, Accenture had collected experience on I4.0

technologies, particularly internet of things (IoT) applications, even if in other business areas.

Biesse launched an IoT-based project in 2016, which makes it possible to receive performance and operational data from customers with the help of sensors present on the machinery.

There are additional local businesses who aren't part of the furniture cluster but have launched projects based on technology and Industry 4.0 from the beginning. This is the case with Benelli Armi, an armaments manufacturer that began investing in I4.0 by expanding its industrial facility to include a room dedicated entirely to I4.0 technology for fully automated material handling. Another key local company, which also does not belong to the furniture sector, is Schnell. This company stands out for the acquisition of a robot called APPS that supports the production line.

Recognizing the potential beneficial effect of I4.0-related technologies prompted certain significant local knowledge providers and technology hubs to engage in efforts aimed at improving their ability to analyze and exploit these new technological prospects. COSMOB is an international technological center focused on the furniture industry. Since 2015–2016, COSMOB has recognized the significance of research on these topics and has taken several measures to address them.

- Dissemination effort

The approval of the National Industry Plan mentioned above brought numerous tax benefits, which prompted Pesaro ID companies to consider adopting the technologies, to benefit from the tax incentives.

This helped local pioneering companies progress toward Industry 4.0. Biesse continued to work on the crucial SOPHIA Project. During the second phase of the project, information about it was disseminated through trade shows.

As a result of the further deployment of SOPHIA, Biesse became more aware of the implications of various I4.0 technologies, such as IoT, Sensoring, and Big Data, and initiated an industrial PhD project in partnership with the University of Urbino's Department of Economics. The project began in 2018 and focused on applied I4.0 and servitization research. Other research institutes, such as the Marche

Polytechnic University and the Polytechnic University of Milan, were engaged in the creation of the SOPHIA platform.

A greater emphasis on the digitalization of production and an attempt to integrate products with Industry 4.0 technologies, based on Artificial Intelligence or Big Data, among others, was observed. This helps local institutions and business associations to implement first monitoring activities.

- Pursuance of institutional upgrading

The most recent stage is characterized by continuing to encourage and promote the development of different projects, focusing on SMEs. There is also an awareness of the complexity of new technologies and a series of policy measures are being implemented, consisting of financing plans, the creation of new projects and the establishment of the competence centers.

Local enterprises are increasingly likely to build more solid and formal networks to undertake I4.0 initiatives, in addition to updating the regional and local institutional framework.

Local active enterprises, on the other hand, seek aggregations to pool complementary resources and competencies. Sinergia is a member of Overlux, a formal network that includes local enterprises – including academic spin-off firms from local institutions – as well as companies from beyond the ID. This group of firms is dedicated to guiding organizations toward I4.0 by implementing cutting-edge IoT solutions.

The "Open Factory" is a bottom-up idea based on efforts established in and by various creative enterprises involved in Industry 4.0. Even though they are not in the furniture business, companies like Benelli Armi have been eager to build offices and plants in the area to foster a feeling of community.

In conclusion, it is possible to say that I4.0 knowledge dissemination in Pesaro ID has been characterized by a mix of "conventional" and "innovation" diffusion patterns, which have been formed by the district's existing structure and interaction processes in recent years.

Traditional ID actors have begun to approach I4.0, but with varying degrees of success in disseminating associated knowledge. On the one hand, significant ID companies like Biesse and IMAB undertook I4.0 projects with an "independent" approach – in terms of local technology trajectories and ambitions – that was already in place before I4.0 became popular.

On the other hand, other key players have also been very active in their outreach efforts. Companies such as COSMOB and Sinergia have established relationships with both other local key players and partners outside the district to fulfill their role as knowledge providers and gatekeepers.

Sinergia has been able to integrate technological and business-related knowledge by implementing I4.0 consulting services, while COSMOB has tried to translate I4.0 opportunities into furniture industry-specific projects, as shown by its FabLab project.

Research will be conducted on enterprises in the Made in Italy sectors situated in Northern Italy to further assess the deployment of Industry 4.0 technology in Italian companies.

It has been considered interesting to carry out this study since the companies located in this area have great relevance in the Gross Domestic Product (GDP) and in the national competitiveness in international markets.

First, we will analyze whether companies that adopt at least one of the digital technologies (robotics, big data and cloud, laser cutting, augmented reality or additive manufacturing among others) have higher functions. For this purpose, a set of regression analyses has been carried out with a dummy variable of whether they are adopters or, on the contrary, non-adopters. The variables firm's industry, average number of workers 2014-2016, and firm's age as the primary independent factors, and the normalized performance indicator (EBITDA/Sales, ROS, ROA, and ROE) as the dependent variable.

Regression analyses between Adopters/No-adopters and firm performances

Independent variables	EBITDA/Sales		ROS		ROA		ROE	
	B	*t*	*B*	*t*	*B*	*t*	*B*	*t*
Constant	1.142*	13.642	1.165*	14.238	1.300*	13.089	1.108*	9.934
Firm's industry	-.010	-.987	-.028	-2.926	-.033	-2.816	-.024	-1.678
Firm's age	.001	.621	.001	.479	.002	.689	-.001	-.367
Firm's average number of employees	.000	-.486	.000	1.069	.000	.879	.001	1.773
Adopters/No-adopters	.601*	5.097	.345**	2.959	.416**	2.972	.364°	2.131

Note: N=1,044; * p = .000; ** p < .005; ° p < .05

Illustration 28. Regression analyses between Adopters/Non-adopters and firm performance.

Image source: Department of Economics and Management, University of Padova, Bettiol, M., Capestro, M., Department of Economics and Management, University of Padova, di Maria, E., Department of Economics and Management, University of Padova, Furlan, A., & Department of Economics and Management, University of Padova. (2019, June). *IMPACTS OF INDUSTRY 4.0 INVESTMENTS ON FIRM PERFORMANCE: EVIDENCE FROM ITALY*.

The results of the analysis show that being an adopter is related to higher performance in all selected indicators.

We conduct a second regression to see if the number of technologies adopted has an influence on company performance, with the primary independent variable being Sum of technologies adopted. We use two forms of regression, linear and quadratic, to see if the relationship between the number of technologies used and the results follows a U-shaped pattern.

Regression analyses between *Sum of technologies adopted* and firm performances

Perfo	Regression	Model resume					Par. estimates		
		R	*F*	*df1*	*df2*	*Sig.*	*B*	*t*	*B*
EBITDA /Sales	Linear	.009	9.365	1	1006	.002	1.142	.161	
	Quadratic	.023	11.605	2	1005	.000	1.126	.607	-.139
ROS	Linear	.004	4.027	1	957	.045	1.053	.103	
	Quadratic	.010	4.676	2	956	.010	1.043	.377	-.084
ROA	Linear	.004	3.611	1	1002	.058	1.185	.119	
	Quadratic	.012	6.255	2	1001	.002	1.169	.544	-.132
ROE	Linear	.005	4.818	1	932	.028	1.001	.168	
	Quadratic	.007	3.452	2	931	.032	.993	.420	-.080

Note: N=92

Illustration 29. Regression analyses between Sun of technologies adopted and firm performances.

Image source: Department of Economics and Management, University of Padova, Bettiol, M., Capestro, M., Department of Economics and Management, University of Padova, di Maria, E., Department of Economics and Management, University of Padova, Furlan, A., & Department of Economics and Management, University of Padova. (2019, June). *IMPACTS OF INDUSTRY 4.0 INVESTMENTS ON FIRM PERFORMANCE: EVIDENCE FROM ITALY*.

Based on the data in the table above, it can be stated that a company's number of technologies embraced has a favorable impact on its outcomes. The R square of the quadratic regression is also bigger than the R square of the linear regression, and all B values are negative. This result is an inverted U-shaped connection between the number of technologies and performance.

To verify this, another regression analysis will be performed between the variables "Sum of technologies adopted" and the square of this variable as independent variables on the company's results.

Regression analyses between *Sum of technologies adopted* and firm performances

Independent Variables	EBITDA/Sales		ROS		ROA		ROE	
	B	*t*	*B*	*t*	*B*	*t*	*B*	*t*
Constant	1.126*	33.267	1.043*	31.592	1.169*	29.183	.993*	20.716
Sum of techs	.607*	4.625	.377**	2.909	.544*	3.494	.420°	2.202
Sum of techs²	-.139*	-3.705	-.084°	-2.304	-.132**	-2.979	-.080	-1.443

Note: N=92; * p = .000; ** p < .005; ° p < .05

Illustration 30. Regression analyses between Sum of technologies adopted and firm performances

Image source: Department of Economics and Management, University of Padova, Bettiol, M., Capestro, M., Department of Economics and Management, University of Padova, di Maria, E., Department of Economics and Management, University of Padova, Furlan, A., & Department of Economics and Management, University of Padova. (2019, June). IMPACTS OF INDUSTRY 4.0 INVESTMENTS ON FIRM PERFORMANCE: EVIDENCE FROM ITALY.

This supports the inverted U-shaped connection hypothesis (for the ROE the result is not notably). However, because there is a large numeric disparity between the two sides of the variable Sum of technologies adopted, these results must be seen in the context of the sub-sample investigated. They will need to be improved as the number of adopting enterprises analyzed increases.

To conclude this study, we will analyze the impact on companies that believe they have one, two, three or more technologies, i.e., we include in the sample those companies that have at least one technology.

Regression analyses between the number of technologies adopted and firm performances

Independent Variables	EBITDA/Sales		ROS		ROA		ROE	
	B	*t*	*B*	*t*	*B*	*t*	*B*	*t*
Constant	1.134*	34.288	1.052*	32.530	1.180*	1.180	1.024*	21.745
Only one	.846*	5.158	.469°°	2.773	.574**	.574	.096	.393
Constant	1.155*	34.869	1.062*	32.946	1.189*	30.457	1.000*	21.529
Only Two	.537°	2.553	.266	1.307	.596°	2.410	1.038*	3.580
Constant	1.168*	35.203	1.065*	33.082	1.205*	30.852	1.026*	21.992
Three or more	.043	.186	.193	.864	-.048	-.172	.082	.245

Note: N=92; * p = .000; ** p < .005; °° p < .01; ° p < .05.

Illustration 31. Regression analyses between the number of technologies adopted and firm performances

Image source: Department of Economics and Management, University of Padova, Bettiol, M., Capestro, M., Department of Economics and Management, University of Padova, di Maria, E., Department of Economics and Management, University of Padova, Furlan, A., & Department of Economics and Management, University of Padova. (2019, June). *IMPACTS OF INDUSTRY 4.0 INVESTMENTS ON FIRM PERFORMANCE: EVIDENCE FROM ITALY*.

The findings show that only sub-samples of enterprises that adopted one or two technologies showed substantial positive connections between technology adoption and performance.

The regression results reveal a favorable relationship between the adoption of Industry 4.0 technology and business performance. This backs up the theory that Industry 4.0 is good for business development.

To conclude this section, a few companies that have influenced the effective deployment of advanced manufacturing technologies will be analyzed.

- ABB Dalmine

This Italian plant located in the north of the country belongs to ABB's Italian division. They are engaged in the manufacture of a high range of medium voltage products and a variety of switching devices that meet a range of needs such as controlling, protecting, and isolating power systems.

It is characterized by the fact that the managers of this plant aim to improve quality and delivery times, something that makes them stand out from the competition. This attitude, led to the adoption in 2015 of technologies related to Industry 4.0 in the value creation processes.

These innovations were made with the aim of building a smart factory, thanks to the optimization of internal processes, to reduce manufacturing costs, increase quality and improve delivery times. The top management of this company played a crucial role as they actively participated in meetings and activities to promote learning in this field.

The ABB Dalmite Smart was a project organized in a series of homogeneous activities called waves; it included a roadmap for implementation; training activities for all personnel who needed to interact with the new technology.

The efforts have resulted in improvements in operational performance, such as quality and on-time delivery, by reducing the time it took to complete assembly tasks, conduct testing, and build ad hoc tools for process improvement by the beginning of 2017.

A year later, the Italian Minister of Economy named this factory as the model for Industry 4.0 orientation in Italy, as a lighthouse. The robotics, energy, and automation company want to be "carbon neutral" in all its operations by 2030, while also expanding its industrial plant to boost profitability.

- ASO hydraulics and pneumatics.

This Italian company supplies a wide range of chrome-plated steel products for hydraulic rollers and is a world leader in the pneumatics and hydraulics sector, although it has recently been endangered by cost competition.

It is characterized by offering high flexibility in its product range. With the Industry 4.0 initiative launched at the end of 2015, the business strategy focused on trying to integrate the supply chain by giving customers the opportunity to configure items, checking availability in real time by locating an item when it is in the production process.

Customers were allowed to access the e-marketplace at the start of 2017, marking a watershed moment for the ASO business model and the industry. As a result of this endeavor, the corporation was able to maintain its market leadership.

- ROLD

This Italian company dedicated to the manufacture and development of electronic components, such as switches or specialized door locking devices, is one of the main partners of the world's appliance manufacturers.

ROLD is characterized by the quality of its components, as investments reach approximately 8% of annual sales in innovation. The industry 4.0 adoption initiative came with the opportunity to jointly develop an out-of-the-box platform with Samsung (ROLD's main customer).

The short-term goal is to be able to monitor processes in real time to optimize them and develop an innovative platform; the long-term goal was to become a key digital advisor in the home appliance market.

The Innovation Director oversaw numerous adoption activities and the company's top management played a crucial role in the implementation of the new technologies. The cross-functional teams involved in the different steps of the initiative included electronics, mechanics, and IT. A formal blueprint was also defined with the route to be followed to achieve the expected results. This information is continuously available on the SmartFab platform.

After a year of development, ROLD established a separate business unit specialized to SmartFab sales, allowing ROLD to access a new market. The World Economic Forum included ROLD to its network of 'Manufacturing Lighthouses' in early 2019 because of its effective application of Industry 4.0 technologies, which has resulted in financial and operational effects.

Barriers to I4.0 and benefits of I4.0 in Italy

As is the case for Spain, the execution and implementation of Industry 4.0 technologies brings numerous benefits. At the same time, the implementation of these technologies presents some barriers.

Information on the variables influencing Industry 4.0 deployment is scarce, and it is mostly focused on SMEs. Because the research of possible situations is typically intricate, the success criteria are largely relied on expert opinion. As a result, three essential success elements for implementing Industry 4.0 in SMEs may be identified: staff training, undertaking research before to any Industry 4.0 project, and frequent utilization of accessible corporate data.

Without confining themselves to SMEs, several businesses have done analyses to better grasp these essential elements. Top management support, staff skills, project management, project objectives, change management, and lean management are among the up to ten items highlighted by Sony as being relevant to Industry 4.0.Companies like Reaiche, Hoyer, and Gunawan, on the other hand, have identified fourteen factors that may be relevant to the adoption of new technologies: “political support, IT standardization and security, corporate and institutional cooperation, assessment of available costs and financing options, available knowledge and education, pressure to adapt, perceived implementation benefits, strategic considerations, IT infrastructure maturity, internal knowledge and skill, and pressure to adapt.”

Studies on critical factors are quite recent and have been carried out using different typologies and approaches, making the results difficult to analyze. On the other hand, it is interesting to study and understand the implementation of advanced manufacturing technologies also known as AMT. This term is used to understand technologies that support design activities (such as engineering or computer-aided processes), manufacturing activities (robotics, flexible manufacturing systems or group technology among others) and control activities (including data exchange, barcodes, and office automation).

AMT adoption research can reveal the aspects that influence connection and intelligence compliance in new manufacturing systems. Successful AMT implementation is related to process factors such as contextual or organizational variables.

The construction of committees and project teams, on-going and on-the-job training, and the establishment of a clear, external emphasis on aims and objectives are among the fundamental features for successful AMTs, according to a variety of sources (such as quality improvement and the delivery of superior and reliable service).

In terms of contextual factors, company size can be a critical factor in understanding the performance of automated systems. In general, companies with a larger number of employees have higher AMT investments and higher performance than companies with a smaller number of employees. The extensive literature on ERP (enterprise resource planning) adoption critical factors defines information and education as one of the most relevant single factors for ERP implementation in regions or countries.

When flexibility is a key component of a company's production strategy, AMT is the best option. En la siguiente tabla se resumen las contribuciones de la literatura los factores más relevantes que afectan al despliegue efectivo de AMT, incluyendo los factores contextuales and the adoption-related factors.

	Adoption-related factors					Contextual factors		
Reference	Top management support	Project team	Project goal	Project plan	Training	Firm size	Competitive priority	Organizational culture
Anderson and Schroeder (1984)	x	x	x	x	x			
Boyer, Ward, and Leong (1996)						x		x
Co, Eddy Patuwo, and Hu (1998)	x	x			x			
Ettlie (1988)								x
Jonsson (2000)						x	x	x
Machuca, Díaz, and Gil (2004)					x			
Meredith (1987)								x
Ngai, Law, and Wat (2008)	x			x	x			
Sohal (1996)	x	x			x		x	
Small and Yasin (1997)		x				x		
Voss (1988)	x	x	x	x	x			

Illustration 32. Summary of the technology implemented.

Image source: Rossella Pozzi, Tommaso Rossi & Raffaele Secchi (2021): Industry 4.0 technologies: critical success factors for implementation and improvements in manufacturing companies, Production Planning & Control, DOI: 10.1080/09537287.2021.1891481

When it comes to improvements driven by Industry 4.0 implementations, let's consider incremental/evolutionary versus radical/revolutionary improvements. Industry 4.0 can itself be considered as a 'revolution' or as an 'evolution'.

The adoption of AMT often provides clear measures of improvement: improvement in manufacturing performance such as lead times, work-in-process inventory levels and inventory turns; increased return on investment and profits; and accuracy in the information used.

Even though the measured metrics of improvement are obvious, these studies provide no indication of the incremental/evolutionary or radical/revolutionary influence of technology adoption.

From other types of studies, such as technological innovation, process improvement or business model improvement, there are the two key approaches to improvement mentioned above (incremental/evolutionary versus radical/revolutionary). Technological innovation, business model and process improvement are the key differences between the two approaches.

Kim, Kumar, and Kumar report in 2012 the following dimensions to distinguish incremental/evolutionary and radical/revolutionary technological innovation: target customer or market (existing vs new), level of change (little versus major), potential risk (small versus high), and output (improvement versus new). While the dimensions are known, the methods for expressing their levels are not.

As far as the process improvement part is concerned, based on reengineering, the differences between incremental/evolutionary and radical/revolutionary improvements can be defined as follows: modifications to existing processes (improving or reinventing them); the benefits obtained (long-term or short-term); the expected improvement (moderate or substantial); people driving the change (employees or top management); the risk involved in integrating changes (little or a lot); the use of new technologies (little or a lot).

In short, a revolutionary or radical approach is described as a fundamental rethink in the process, requiring high investment, more research and development time, since it starts from a new concept. While an incremental or evolutionary improvement creates value on an existing product by incorporating new improvements.

After analyzing both the critical factors in the implementation of new technologies and the types of changes that may arise, the numerous advantages, as well as the barriers or disadvantages that this implementation entails, will be mentioned.

Industry 4.0 plays a fundamental role in everyday life and is an important part of the research and innovation themes identified as important for the future of the manufacturing sector in Italy. Thanks to the use of complex technological systems such as sensors that perform constant monitoring, it is possible to control actions carried out on work lines and ensure proper operation.

The change introduced with Industry 4.0 is not only at the technological level, but also influences the labor level, causing a transformation in the management of the company; it aims to achieve greater flexibility, quality, speed, productivity, and greater competitiveness with the product.

Another benefit is that the industrial production model tends to become increasingly customized, as it can design, produce and market products according to the customer's request. Positive effects at the competitive level can derive from greater flexibility and better responsiveness to the market, from a faster transition from prototype to product.

New technological solutions can also make it possible to exchange data and information in real time on the production capabilities of many companies. In this context, new technologies support the integration of the value chain, from product design to production management and the provision of after-sales services.

The advancement of new technologies opens new possibilities for the interconnection of manufacturing resources, accelerating the renewal of business models while considering technological areas that are considered strategic for the implementation of Industry 4.0, such as advanced robotics, advanced control and supervision of manufacturing processes, the digital factory, the Internet of Things and Big Data, and Cyber Security.

Two issues must be considered when it comes to the influence on the workplace: first, the adoption of more computer-guided machines and cutting-edge robots will necessitate individuals with specialized professional skills and proper training. Labor experts, on the other hand, warn of the dangers of a massive drop in workers in jobs that need more repetitive tasks. This causes a lot of anxiety among these individuals, who regard the development as a significant danger to their jobs.

These applications require highly qualified personnel, young graduates able to cope with the professional requirements needed to perform the job.

If we analyze the technical-economic implications of the application of Industry 4.0, we can speak firstly of the benefit of achieving more flexibility thanks to the production of small lotuses at high costs, since they have a high degree of customization and adaptation to market demand.

A second possible benefit is related to the agility to move from prototype to production thanks to innovative technical solutions. Shorter set-up times (time used to replace parts or to adapt a process) and thus increase productivity can be considered as the third benefit.

Another positive aspect is linked to obtaining higher quality products, generating less waste thanks to the use of devices such as sensors that allow monitoring the process and thus obtaining quality processes reducing errors.

Additionally, the processes are safer because there is better interaction and agility between man and machine, improving the ergonomics of the place. In terms of sustainability, there has been a reduction in energy consumption and emissions.

In terms of limitations, there is still a need for training related to this topic so that these processes are well received by society as a whole and can be improved.

Discussion

As we have been able to analyze throughout this project, Italy and Spain are remarkable economies, which have a high level of progress with respect to their digital competitiveness (twentieth and ninth according to the DESI 2021 report, respectively).

Digitization in Italy occurred later than in the rest of the European countries, which is reflected in its 20th place in DESI 2021, obtaining a score of 45.5. Although this result is below the European average, Italy has moved up from the 25th place it obtained in the previous year's report, noting an increase in digitization and in the implementation of technological infrastructures.

It can be concluded, analyzing the different parameters present in the DESI, that the country is advancing in digital aspects, but lags in terms of human capital and skills. These significant differences in both basic and advanced digital skills can create a digital exclusion of a significant part of the population, as well as reduce the capacity for innovation and business development.

A fundamental and outstanding role is the role of e-commerce in the turnover of small and medium-sized enterprises, i.e., SMEs. The e-invoicing figure is almost three times higher than the European average and has been affected by an incremental increase since 2018.

The use of technologies based on artificial intelligence and big data remains relatively low. Italy performs better than the EU in terms of offering digital public services for businesses and open data. However, it is below the EU average in terms of offering digital public services for citizens and the availability of pre-filled forms.

Italy's assets include inventors, job creation, and environmental sustainability. Resource Productivity, Innovative Product Sales, and Design Applications are the three most essential indicators. The significant rise from 2019 to 2021 is due to increased performance in measures based on innovation survey data and broadband adoption.

Internal product inventors with no market novelty and internal business process innovators are both above-average in Italy. On climate change indices, Italy outperforms the rest of the world. Internal business process inventors and market novelties on climate change indices, Italy outperforms the rest of the world.

The different plans or strategies proposed by the Italian government, such as "The National Strategy for Digital Skills" represent an opportunity and a relevant advance to close the existing gaps in certain fields.

As far as Spain is concerned, it is gaining momentum in terms of digitization, and is beginning to position itself close to the relevant indicators. It ranks ninth in the DESI report and can be classified as a rising economy.

In terms of digital public services, it performs well thanks to the digital strategy implemented in the central administration. The area of connectivity achieves an increase, although there are notable differences between rural and urban areas.

In recent years, human capital has risen, but there is still room for improvement, especially in the indicator of specialists in information and communications technologies.

The integration of digital technologies has increased, as has the number of small and medium-sized companies selling through the Internet. However, technologies such as artificial intelligence, the cloud and the use of big data are not being sufficiently exploited.

Human resources, digitalization, and environmental sustainability are three of Spain's assets. Sustainability in the environment PhDs, resource productivity, and sales of new items are the three most essential metrics. The most recent findings have remained unchanged. Improvements in tertiary education, non-R&D innovation spending, innovation spending per employee, product innovators, and HR job-to-job mobility have been counterbalanced by declines in business process innovators, PCT patents, trademark and design applications, and environmental-related technologies. Spain has a higher-than-average share of non-innovators with the ability to innovate, as well as a near-average score on climate change indicators.

As in Italy, there are plans and initiatives to promote the digitalization of the country. Such as, for example, the case of Digital Spain 2025, which aims to improve aspects such as 5G connectivity, connectivity, and network security, among others.

According to the European Innovation Scoreboard 2021 both countries are moderate innovators; Spain has increased over time the performance in relation to the EU and Italy has considerably increased these results.

Both countries need to increase their involvement in the training of young people in new technologies to encourage the creation of new jobs and thus develop this field. Another factor present in both countries is the inequality between the different areas; in Italy, the central and northern areas are much more industrialized than the south of the country; in Spain, this unevenness is found between rural and more urban areas.

In general, Spain is more digitized than Italy in terms of connectivity and adaptation to new technologies. Even so, the level of digitization in Italy has increased considerably in recent years, with a particular focus on small and medium-sized enterprises, in response to the need for innovation and digitization of manufacturing processes to increase performance.

Conclusion

We may conclude that Industry 4.0 pushes for technology solutions to optimize production processes, promote industrial automation processes, and stimulate collaboration between enterprises through integrated logistics management, as has been researched throughout this study.

To carry out the activities involved in Industry 4.0, companies need to equip themselves with the necessary skills, selection practices and trained personnel to perform such tasks.

When making smart investments in the factory of the future, we may encounter challenges such as security when using such technologies, interoperability, data sensitivity, the gap in technical skills and good handling of data growth.

The countries studied are on track to achieve a good degree of digitalization and thus increase the flexibility and performance of manufacturing processes.

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