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Initial study on the level of development of Blockchain technology in SUDOE regions

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EUROPEAN UNION
BLOCK4Coop
European Regional Development Fund

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INTRODUCTION

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1. INTRODUCTION

1.1 Purpose and scope of the report

Mistrust in conducting business between players that do not know one another is a challenge that greatly hampers industrial growth in all areas. The possibility of introducing an ecosystem that allows this type of new strategies to be dealt with represents a before and after in business. Furthermore, Industry 4.0 and Services 4.0 currently offer a capacity for interaction, monitoring, supply, business and generation of goods that requires new approaches to continue producing at the rate required by the industrial fabric, without isolating conventional industries.

On the other hand, bringing business logic from the real world to the digital world through digital contracts is an encouraging challenge that is currently beginning to be explored to automate different supply, maintenance and exploitation efforts.

The aim of this study is to explore and explain the above and many more aspects, added value and opportunities that blockchain technologies offer nowadays.

But first of all, it is worth noting that this study is carried out in the framework of BLOCK4COOP project that is financed by the European Regional Development Fund (2014-2020 ERDF) in the framework of the third call of the Southwest Europe Territorial Cooperation Programme (SUDOE).

The objective of the project is to *"contribute to the digital transformation of companies in the participating regions and their competitive improvement through the use of blockchain technology in the developments of Industry 4.0 of organizations, through the provision of information services, advice and interaction between developers and users".*

In this context, the participating regions are the Basque Country, Aragon, Aveiro and Auvergne. In fact, this study is the first intent of exploring the development situation, application level and needs of Blockchain technology in the regions participating in the project.

Therefore, the objective of the study is to reveal the level of blockchain implementation in the above-mentioned regions through the existent support policies and initiatives, start-ups, developers, beneficiaries, and users of blockchain technology. This is also about highlighting the relevant sectors and areas for the application of blockchain technology at the regional level, as well as some prospects of its future development.

Thus, we need to look at the conceptualisation of blockchain technology, followed by its application in the industrial environment as the digitisation process of the industry has accelerated in recent years.

Next, the support policy framework of blockchain technology at the national and regional level was relevant to be explored in this study. Hence, to know better on the blockchain governance, instruments and mechanisms that support its promotion and implementation at private, public and social levels, the strategic framework is showcased in the four mentioned regions.

Likewise, barriers and difficulties regarding blockchain technology implementation at the regional level, such as storage capacity, scaleability and security are tackled in this study.

Finally, intersectoral and interregional collaboration opportunities are also highlighted. In this sense, aspects like servitisation, unlimited use of the platform and established trust by technology are some of the elements that give added value to this type of technology. In addition, its transformative capacity and impact upon business (models) and the working of public bodies are just a few examples that the new technology has to offer nowadays in these initial steps of its implementation.

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1.2 Methodology

The activity necessary to carry out this document is divided into four phases represented at the top of this graph:
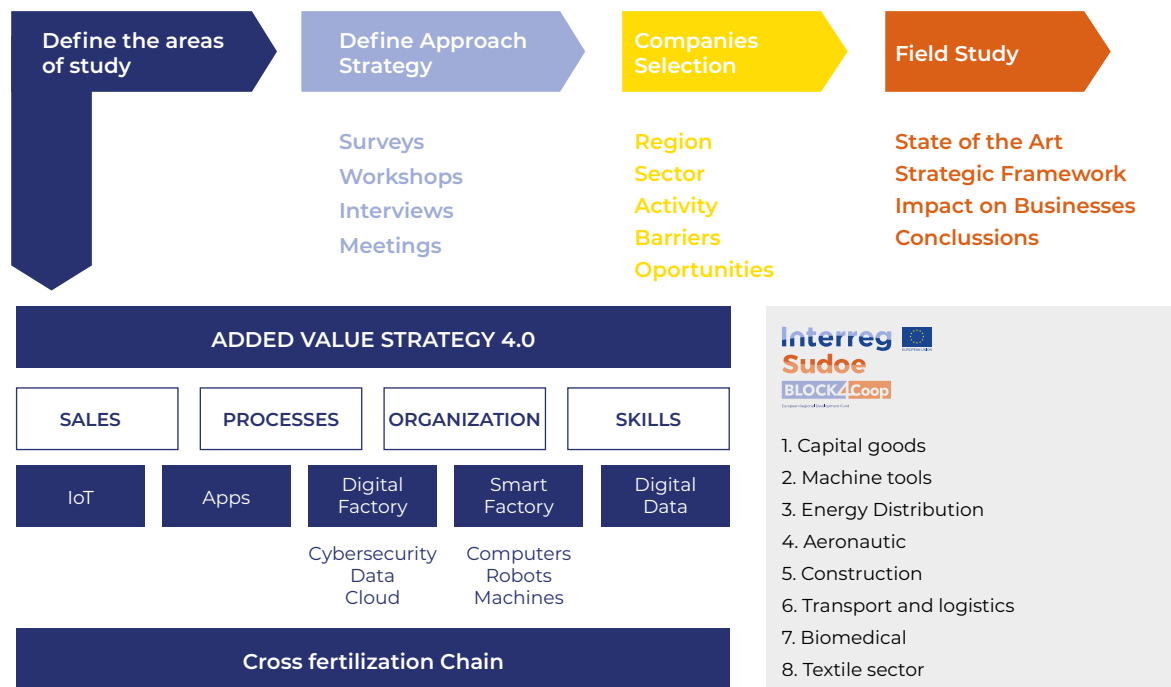

Figure 1: Schematic representation of the activities to be carried out to fomalise this document. It is inspired in the following method: "Methodological Manual for statistics on the Information Society. ICT usage and ecommerce in enterprises. Eurostat, December 2016"

STATE OF THE ART IN THE FIELD OF BLOCKCHAIN

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2. STATE OF THE ART IN THE FIELD OF BLOCKCHAIN

2.1 Conceptualisation of blockchain technology

Blockchain technology aims to enable a public and easily auditable register to be maintained, managed in a distributed manner and without the intervention of reliable central authority. The fact that the register is distributed and managed by a number, which may be very large, of independent and autonomous agents, means that the technology can be useful when there is no reliable authority that can maintain it, promoting decentralisation. This allows operations to be carried out without the need for a central control body.

Blockchain technology makes it possible to get around the difficulty of keeping an inviolable record even when there is no reliable central authority. To maintain security the records in the absence of a central authority, it is necessary to ensure that old records cannot be changed and that false records cannot be added.

To ensure that old records cannot be modified the solution is to chain the blocks in a specific way. In a chain of blocks, each block is a record that is linked, in a chain, to the previous block. Each block contains the useful information you want to record and a summary of the previous block. This summary has an exceptional feature, mathematically guaranteed: it is practically impossible to change the content of a block while keeping the same value of the summary that is saved in the next block. If any block in this chain is changed, it is simple to verify that there has been a change because the summary of the next block does not match the content of that block. Blockchain thus represents a sequence of records, permanent and inviolable.

To ensure that a dishonest agent does not add new blocks with false information, it is necessary to ensure that when the chain is extended with a new block, the overwhelming majority of agents agree with the content of that new block. Since there may be several proposals to add simultaneous blocks (authentic or falsified), it is necessary to have a consensus mechanism in place to ensure that in the end there is only one blockchain, accepted by all. Using as an example the case of property registration, suppose Alice wants to transfer the property of a car to Bob. Properly authenticated, Alice and Bob inform all network agents that the ownership of the vehicle that was Alice's became Bob's. A block that contains this transaction and the summary that allows validating the content of the previous block is then added to the Blockchain, thus making the transaction indelibly recorded.

To ensure that there is consensus from most agents about the content of a new block, there are several techniques. It is not enough to count the agents that agree, because an attacker could create many false agents and use them in an attack on the system.

In the case of Bitcoin digital currency, only agents that present a proof of effort made can add a new block. The stress test consists of solving a complex mathematical problem, which requires excellent computational resources, a lot of time and a lot of electricity. Thus, a dishonest agent (or a small number of these agents) cannot put false blocks in the chain, because they would have to compete with most of the agents that act honestly and verify if the transactions of the new block are real. Other solutions to the problem of ensuring consensus exist and are used by some systems.

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2.2 Application of blockchain technology in the industrial environment

The digitisation of the industry has accelerated in recent years. The industrial fabric is adopting technologies that allow it to respond to new market challenges to improve its products, processes, and services. In this area, the provision of digital value-added services and the guarantees related to digital identity and cybersecurity that facilitate the execution of smart contracts in the entire value chain is increasingly relevant and presents itself as a key opportunity.

To contextualise the relevance of the SmartContract, we can take a look at the evolution of the industrial sector from a technological perspective. In recent years it has evolved from goods focused on mechanical elements, the increasing importance of control systems, the generation of connected goods and, finally, the digitisation of systems where ICTs increasingly play a more relevant role in the value perceived by the client and in the functionality provided.

The next step of the digital transformation in the industry is to allow the exchange of data and services between the industrial companies, then formalise that agreement in a binding way in the form of a digital contract or Smart Contract, and finally make the payment for the transfer of value. All this in a cybersecure and reliable environment, with guarantees that they comply with the established norms and standards. The following table shows a summary of this evolution to contextualise the project and focus on technological challenges.

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The table below shows the evolution of the digital transformation of the industry:

	Capital good	System	Technological Aspects
PAST	**CONVENTIONAL**	Metal-mechanical precision device	MES: interoperability in plant, processes, etc.
	SMART	Sensors and control systems (Electronics and Software) to improve precision, generate more complex geometries and reduce the influence of the operator on the product. All this by means of PLCs and numerical controls of the machine in local	Control: process / quality / etc. SCADA: monitoring Remote telecare through internet access to the control screen: ("remote desktop")
	CONNECTED	Electronics and Software increasingly relevant (local) Plant interoperability (local)	Control software with relevance in precision and added value Local machine HMI Teleservice - access to all elements of the machine's network: control, HMI, drives, remote cards, etc.
PRESENT	**DIGITAL**	Electronic and Software keys (local, adhoc) Interoperability between plants (local, adhoc) Joint digital services between components and machines	Control and monitoring software with relevance in precision and added value Local and remote machine HMI Remote monitoring and services Services offered based on the client's platform or own platform to choose from and with a significant integration effort.
FUTURE	**DECENTRALIZED CYBER SECURITY**	After integration it is necessary to ensure cybersecurity in three large blocks (I) Cybersecurity of systems: access to machines without compromising the security of the network in which they are integrated. (II) Guarantee the availability of the machine. (III) The authenticity of the data from the sensor to the centralising node and the immutability of that data stored in the node	Cybersecurity certification Analysis of vulnerabilities and risks of cyber attacks Threat and risk mitigation tools Monitoring the network from a cybersecurity point of view Communications with fingerprint Immutable and Distributed Logbooks (BlockChain)
	CYBERSECURE BUSINESSES	Thanks to the authenticity and immutability of the data, the contracts are traceable and auditable. Generate Business based on formalising the conditions of use through auditable digital contracts and monitor them appropriately	Allow the exchange of data and services between industrial companies. Formalise that agreement in a binding way in the form of a Smartcontract. Make the payment for the transfer of value.

Table 1: Digital transformation of the industry. Ikerlan

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People are willing to do such amazing things when they trust the figments of their collective imagination. Trust is the raw material from which all types of progresses are minted".

Inspired from Homo Sapiens, Yuval Noah

Business digitisation is not only visible in products, but also in processes. The traditional linear value chain is transformed into decentralized networks of digital values. Thanks to digitisation, the exchange of data and applications between different companies, the added value is generated in the form of new advanced products and services. The result of this is that, beyond the native internet companies, digital business models are also possible in conventional industries, and more specifically for good manufacturers.

Therefore, a new concept is needed based on a DIGITAL PRODUCT/SERVICE that corresponds to a connected good, managed in the fleet and that interconnects within the value chain with assets and services of other client companies. The leap proposed should be based on the development of NEW CYBER-INSURANCE BUSINESS MODELS where building trust through technology will be the key to exponentially multiplying the collective potential of companies in the industrial sector.

This leap in mutual reliability should be implemented based on the disruptive use of technology. More specifically, the general conclusion of the BLOCK4COOP project is to develop and integrate the digital identity of assets and their immutable registration through Blockchain to create reliable value-added services based on Industrial Smart contract in the industry.

The potential of this type of contract is that they would be executed within the Blockchain network that has been defined and that supports them, without the need for a third party to act as an intermediary, or to validate it. The benefits are the speed in the execution of the transaction or action, simplicity to carry out this process and that, financially, it is very inexpensive to implement it.

When we talk about transactions, it does not have to be a money transfer, it can be anything that can be implemented in a smart contract, such as executing an action on a specific day, releasing the password from encrypted files, executing a guarantee or purchase options, putting a product in beta for sale when a certain number of pre-sales is reached, etc. To an extent and in a very simplified way, they are like database triggers, but with immutable data, both external and internal to the network.

With Smartcontracts under blockchain, the central entity or intermediary entity disappears, since the success or failure clauses of the transaction or action are determined, accepted by both participants through their digital signature and are public so that everyone can see them.

Therefore, this technology will explore the possibility of creating technologies, tools and solutions to create new digital business models for manufacturers of capital goods. The following image schematically represents the idea behind the project in a similar way to that used by the maps of the metro transport network of cities.

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Company 1	Company 2
Company 3	Company 4
Company 5	Company 6
Company 7	Company 8

Netwotk of technological assets shared between industrial companies

A smartcontract formalizes a process in a binding way

The SmartContracts of a company

The SmartContracts of an ecosystem of different companies

Figure 2: Schematic representation of a network of technological assets to be shared, conditions are established that relate these assets (the smartcontract), and each company deploys different smart contracts that increase the quality / efficiency of its processes. In this way each of the participating companies will generate a different network of smartcontracts under cybersecure conditions (last image on the right)

The possibilities are almost infinite, for example functionalities in these activities: Maintenance, Warranties, Productivity, Quality. Good manufacturers are paying more and more attention to servitisation because the market demands it. This brings with it the possibility that the client might not trust the data for which a service is being charged, which Blockchain helps to solve.

Blockchain technology offers manufacturers the opportunity to position themselves through a value-added offer based on digitisation. In the race to position oneself in the market, the competitive difference lies in the ability to offer added value on data.

The figures provided by consulting firm McKinsey in the field of digitisation of industrial automation are noteworthy[1] the areas with the greatest potential are those of Edge, IoT platform and smart sensors. The growth of these markets estimated by study is 14% in the cloud, 16% in connectivity and 20% in smart sensors.

In this context, the adoption of servitisation by manufacturers is important for economic reasons since it generates recurring income with a higher margin. Furthermore, there is an increasing demand from clients who are interested in outsourcing these activities.

Likewise, servitisation brings with it the need to offer customer confidence when the charges made are based on data. Currently, these types of transactions are based on the trust that the customer places in the manufacturer or in the value chain, as well as on their own experience in using the asset. By embracing the pay-per-use concept, they run the risk of engaging in disputes based on mistrust of the data chain of custody. The incorporation of Blockchain technologies brings with it the assumption of reliability of the data. Manufacturers have the possibility to offer the customer trust mechanisms to avoid disputes and the customer has mechanisms to verify that the data is correct and has not been tampered with. Hence, Pay-per-use includes any type of payment structure in which customers have unlimited access to resources, but only pay for what they actually use or for the result linked to their use. It is the basis of the transition towards asset servitisation. In the field of Capital Goods, pay-per-use is a concept that is beginning to sound increasingly powerful and that opens the door to free a machining company up to make an investment in an indirect product.

1 Service Industry Hub. "VDMA / McKinsey study (2015) on perspectives of the German engineering / manufacturing industry: What's the role of services?" https://serviceinindustry.com/2015/02/10/vdma-mckinsey-study-2015-on-perspectives-of-the-german-engineering-manufacturing-industry-whats-the-role-of-services/

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As a summary of the potential use of the Smart contract, there is a variation of usage-based payment schemes that move away from traditional ownership of the product towards payment for the use of services or the achievement of results, and these include:

- **Payment per unit of service**: in this model the customer receives a charge each time the service is used. In turn, the service provider is responsible for all life cycle costs and is encouraged to design a product optimised for use, maintenance, reuse of parts or products, and recycling. Examples include RollsRoyce offering TotalCare[2] in gas turbines for its airline customers based on a "fixed dollar per flight hour". Also, Xerox offers "pay per click" scanning, copying, and printing of documents. Likewise, tires are invoiced by Michelin[3] based on the kilometre traveled, the ton transported or the landing, while maintaining responsibility for excessive repairs and maintenance; Philips "pay-per-lux" model[4] which charges only for the actual amount of light consumed.

- **Rental or sharing of the product:** the customer pays to access the product for a certain period and other customers use it sequentially. The supplier provides, controls, and maintains the product. An example of this is the great variety of companies that offer vehicle rental schemes, generally electric, that charge the client based on hourly use: Car2Go, Emov, Zity or Wible, etc. [Comparativa CarSharing[5].

- **Product rental:** the provider retains ownership while the customer has continuous access to the product. The supplier generally controls, maintains and collects the product at the end of the rental contract. An example is MUD Jeans, where jeans are leased to the customer on a monthly subscription basis and returned to MUD Jeans when the customer decides to end the rental.

Focusing the models in the **Capital goods sector**, there is a trend towards servitisation of assets and the adoption of pay-as-you-go schemes for large and small players[6].

2 Rolls Royce Total Care.
https://www.rolls-royce.com/media/our-stories/discover/2017/totalcare.aspx
3 https://blog.signus.es/los-neumaticos-no-se-compran-se-pagan-usarlos/
4 Philips' transition from linear to Circular Economy.
https://www.innovationservices.philips.com/news/philips-transition-linear-circular-economy/
5 https://coches.rastreator.com/actualidad/carsharing-madrid-comparativa-car2go-emov-zity-wible
6 Salvador Trujillo et Al. "Securing the Mondragon Corporation Supply Chain". S4x20 Industrial Cybersecurity Conference. Miami (USA). Jan 2020.

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By 2025, the global share of manufacturers using performance/usage-based contracts is expected to grow to 65%, with 70% of them being a differentiating factor[7]. The potential for pay-per-use to contribute to the circular economy in the form of efficient resource management, increased recycling and reduced waste is also compelling from an economic perspective. The disposable income of European households by 2030 is estimated to be 8 percent pay-as-you-go[8] in a circular economy, relative to the current development path.

Figure 2: Schematic representation of the Blockchain trilemma
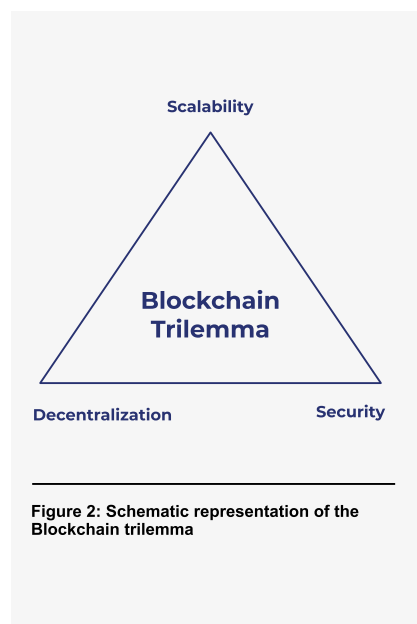
According to the 2020 Circular Vision of the Waste and Resources Action Program, the European Union (EU) could benefit from an improved trade balance of € 128 billion and the creation of 160,000 jobs. Given its dependence on raw materials, a subset of the EU manufacturing sector could potentially realise net material cost savings of up to € 595 billion per year by 2025.

The future of Distributed Ledger Technologies and Blockchain is bright and prosperous. Within distributed ledger technologies, Blockchain is the emerging technology, with almost daily mentions of its applicability to everyday life. It is perceived to provide great opportunities to break with traditional products and services due to the distributed nature of its technology, the persistence and immutability of its records, and its ability to execute decentralized logic through smart contracts. These characteristics make the products and services based on blockchain technology significantly different from those previously developed and based on the Internet, particularly for the sectors related to Industry 4.0 and the consumers's SmartThings.

Briefly, as mentioned Blockchain provides a distributed software architecture that allows agents (humans and/or systems) to interact in many ways (1 to 1, 1 to N, N to M) without a central authority. In the absence of a central authority, the Blockchain network works cooperatively.

Each node in the network executes a protocol that defines a set of rules and verification mechanisms, to guarantee the security, reliability and veracity of interactions (transactions), as well as maximise resilience against failures and cyber-attacks. More specifically, Blockchain technology enables conflict resolution and eliminates information asymmetries by providing a transparent and verifiable record of all transactions made, which cannot be altered retrospectively.

However, there are still certain technical challenges that need to overcome that are interdepended on each other. In fact, it is called Blockchain trilemma or Vitalik's Trilemma as a reference to Vitalik's twitter discussion about the same.

The scaleability trilemma refers to the problem with finding the most efficient strategy between the three main Blockchain fundamentals, scaleability, decentralisation and security. One cannot fully express the potential of one without certain restrictions or drawbacks with the others. Each concept is regarded as one of the core ideologies behind the blockchain protocol and is the centre of immense debate among enthusiasts and architects alike. This trilemma is affecting the deployment of Blockchain within the Internet of Things since the difficulty in extending the ledger to the source where the data is created, the sensor. The following section will describe the state of the art of these challenges under this trilemma structure (see image).

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7 https://ec.europa.eu/docsroom/documents/16595/attachments/1/translations/en/renditions/native
8 The Guardian. 2015. The top three obstacles for policymakers in moving towards a circular economy.
  http://www.theguardian.com/sustainable-business/2015/sep/17/the-top-three-obstacles-for-policymakers-in-movingtowards-a-circular-economy

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In the context of the Industrial Internet of Things, the Industrial Internet Consortium (IIC) and the Trusted IoT Alliance (TIoTA) have begun to collaborate to harness the power of blockchain and the concept of trust/decentralised security to achieve greater security, scaleability and interoperability within IoT ecosystems, both existing and future.

However, it should be noted that the use of blockchain in IoT environments is very recent, with proofs-of-concept with only a maximum of five devices being found in the current literature. Thus, such tests do not reflect the behaviour. of such integration, which is why more realistic deployments and testbeds are required to measure the impact of blockchain technology in the IoT context.

The challenge of moving down to less powerful computing systems lies in the difficulty of maintaining the pace to provide decentralised control, a digital identity in combination with a cybersecurity shield (the surface potentially subject to cyberattack is dramatically expanded).

More specifically, the European Commission is developing the European Blockchain Services Infrastructure (EBSI), which will implement a self-sovereign identity (SSI) and an interoperable digital portfolio. Self-Sovereign Identity (SSI) is based on validating identity simply by accepting a "verifiable credential" issued to the user by competent and reliable identity authorities. A non-digital equivalent of this would be the paper passports issued by the relevant government authorities that we store in a secure location and present as evidence when needed. A credential is, therefore, the evidence that proves the veracity of a fact, capacity, status, etc. associated with a certain identity.

In this way, it is the user who has custody and complete control of their data, sharing only that which they wish to and when they wish to, guaranteeing the immutability, confidentiality and traceability of the data. However, in the industrial digital world, the Self-Sovereign Identity (SSI) is not so simple, since a verifier is a machine and the credential is not a physical document to inspect but is a digital document. Therefore, in order to verify a digital credential, two problems must be solved:

- The **format of the credentials** must be standardized as it will be verified by machines that expect a specific format. The World Wide Web Consortium (W3C)[9] is developing a digital credential standard through verifiable claims and three actors: issuer, owner and verifier[10]. The strength of the test depends on the degree of confidence that the claiming verifier has in the claiming issuer. For example, if a bank (issuer) issues a test that says a user (holder / owner) has a certain credit card number, a merchant (verifier) can trust the test if they have a high degree of trust in the Bank.

- A **standardised method** is required to verify the source and integrity of credentials. In this case, the use of a traditional public key infrastructure (PKI) is usually suggested[11]. The browsers rely precisely on certification authorities (CA) to be able to verify the authenticity and integrity of the credentials presented to the user. However, obtaining certificates takes time and effort and, furthermore, if a CA makes a certificate error, or a service stops working, the entire system might fall apart if it is fully centralised. Therefore, a more secure distributed method is needed to verify the public key of an issuer, and thus test the authenticity of the credential. Blockchain technology solves the problem by proposing decentralized PKI (DPKI) architectures.

9 W3C España,» [on line]. Available: https://www.w3c.es/. [last access: Feb 2020].
10 W. España, «Verifiable Credentials Data Model 1.0,» [on line]. Available: http://www.w3.org/TR/vc-data-model/. [last access: Jan 2020].
11 C. Adams y S. Loyd, Understanding PKI: Concepts, Standards, and Deployment Considerations, Addison-Wesley, 2002.

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Currently, there are various blockchain based identity solutions that allow a secure exchange of user data and the generation of a distributed identity. People do not need to rely on a controller, sender, or processor to comply with regulations to obtain, duplicate, move, send, or secure their data. The main characteristics of the most popular IDS solutions are detailed below.

	Indy	uPort	SelfKey	BlockStack	Veres One	Jocolom
Design Objective	IDS	IDS	IDS	Name system, decentralised storage.	IDS	IDS
Verifiable credentials	Yes (Out of chain)	Yes (Out/In of chain)	Yes (Out of chain)	No	Yes (Out of chain)	Yes (Out/In of chain)
Blockchain	Own code (Permissioned)	Ethereum (Permissionless)	Ethereum (Permissionless)	BitCoin (Permissionless)	Own code (Permissionless)	Ethereum (Permissionless)
TPS	10	15	15	7	200	15
Delay	Few secs	15 sec	15 sec	10 min	Mins or 6-9 hr	15 sec
Cost	Free	Ethereum fee	Ethereum fee	Bitcoin fee	Not defined	Ethereum fee

Table 2: Characteristics of the main current IDS solutions. Indy[12], uPort[13], SelfKey[14], BlockStack[15], Veres One[16], Jocolom[17]

All these solutions have a similar scheme based on issuance of certificates that accredit certain characteristics of an individual. Digital identity solutions for people are a good basis for device identification. Both individuals and devices are all agents with an identity and certain characteristics that identify and define them.

Control systems are a target for attackers due to the impact they can have on a company, an economy, a region or even a country. Due to this attractiveness, attacks are becoming more sophisticated, not only focusing on the final objective but also attacking all the participants in the supply chain, as happened to Software CCleaner[18].

Kaspersky's 2019 report on the state of cybersecurity in industry specifies the lack of communication between the different engineering disciplines and the different security approaches they implement, considering it a major problem[19]. Hence, advanced evidence and information management require monitoring systems that capture the data that occurs within and outside a decentralized system. These systems are based on data sources from different systems, such as intrusion detection systems (IDS), intrusion prevention systems (IPS), honeypots, registry monitoring systems or network monitoring systems in general. They can uncover suspicious activity and target the next steps of the attacks. The risk multiples adding another type of source of data, the sensors installed at different points in the manufacturing chain that collect the values of the process, etc. This data must be decentralised stored and used, with the help of correlation engines, by security information management systems.

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12 Hyperledger, «Hyperledger Indy,» [On line]. Available: https://www.hyperledger.org/projects/hyperledger-indy. [Last access: Jan 2020].
13 «U-Port; We build trust, so you can grow,» [On line]. Available: https://www.uport.me/. [Last access: Jan 2020]
14 «SelfKey,» [On line]. Available: https://selfkey.org/. [Last access: Jan 2020].
15 «Blockstack- Decentralized computing network and app ecosystem,» [On line]. Available: https://blockstack.org/. [Last access: Jan 2020].
16 «Veres One - A Globally Interoperable Blockchain for Identity,» [On line]. Available: https://veres.one/. [Last access: Jan 2020].
17 «Jolocom - Own your Digital self,» [On line]. Available: https://jolocom.io/. [Last access: Jan 2020].
18 [on line] https://www.zdnet.com/article/avast-no-plans-to-discontinue-ccleaner-following-second-hack-in-two-years/,[Last access: May 2020].
19 ARC advisory group, Kaspersky, Thomas Menze "The state of industrial cybersecurity 2019", Report, 2019.

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Another key aspect of blockchain is data integrity. In order to gain confidence in the services to be developed in the project, it is critical to ensure that the data generated is true, both that obtained by the sensors located on the machines, and other relevant data that identifies the machine. In other words, it is necessary to guarantee the integrity of the data.

Data integrity is one of the basic pillars, along with confidentiality and availability, in order to guarantee the security of information in a computer system. These three concepts are known as the "CIA Triad" and are included within the ISO 27001 Standard that defines an Information Security Management System [20, 21, 22].

By data integrity, it is understood that data is consistent over time and has the same value throughout the life cycle from the time that data is generated until it is last consume [23]. In other words, the integrity of the data guarantees, therefore, that the data is not altered or erased by third parties. The information systems that guarantee integrity must also provide methods so that if an unauthorized participant alters the data, it is possible to undo the changes.

To achieve this last part, in various works in the IoT area, it is identified that in addition to integrity and confidentiality, it is also necessary to guarantee the veracity of the identity of the object that issues the data [24].

A decentralised network such as Blockchain requires automatic handling of the information from these heterogeneous sources. In addition, such automated support should deal with evidence traceability management, impact analysis, and compliance assessment. This is why continuous verification of the state of the evidence is required. Some studies use machine learning processes to detect abnormalities in ICS systems [25, 26, 27]. These anomalies are usually related to attacks, although there may also be a situation that is an anomaly in the manufacturing process.

This is in line with Denney et al. who already proposed in [28] the use of monitors to observe events together with deviations of the variables of assurance of the threshold values in a defined time interval. However, as also mentioned in the same paper, "there is not enough clarity about the evolution of security reasoning based on monitored data." Detecting and monitoring security events and incidents is crucial, as specified in [29] "Management of information security incidents".

In addition to these monitoring techniques, there are others based on mitigating vulnerabilities due to traffic obfuscation. These mechanisms allow deployment on already installed systems without modifying the configurations or changing the architecture.

The objective and concrete technological leap in this proposal, from the point of view of security monitoring, is to alert of possible fraud in the processes involved in Smart contract. For this, an event and alarm system will be combined with a Smart contract Data analytics that allows the detection of vulnerabilities, collecting information about those events and the detected vulnerabilities. In addition, a system will be developed to secure typical architectures without changing existing configurations.

20 Lambo, T., "ISO/IEC 27001: The future of infosec certification", ISSA Journal, November 20.
21 Fernández-Caramés, T. M., & Fraga-Lamas, P. (2018). A Review on the Use of Blockchain for the Internet of Things. IEEE Access, 6, 32979-330.
22 Hamad, S. A., Sheng, Q. Z., Zhang, W. E., & Nepal, S. (2020). Realizing an Internet of Secure Things: A Survey on Issues and Enabling Technologies. IEEE Communications Surveys & Tutorials.
23 Liu, B., Yu, X. L., Chen, S., Xu, X., & Zhu, L. (2017, June). Blockchain based data integrity service framework for IoT data. In 2017 IEEE International Conference on Web Services (ICWS) (pp. 468-475). IEEE.
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29 ISO/IEC 27035:2011 [ISO/IEC 27035:2011] Information technology — Security techniques — Information security incident management https://www.iso.org/standard/44379.html.

STRATEGIC FRAMEWORK FOR SUPPORT AND PROMOTION OF BLOCKCHAIN TECHNOLOGY AT THE NATIONAL AND REGIONAL LEVEL

3.

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3. STRATEGIC FRAMEWORK FOR SUPPORT AND PROMOTION OF BLOCKCHAIN TECHNOLOGY AT THE NATIONAL AND REGIONAL LEVEL

3.1 Strategic European framework to support and promote blockchain technology

On 3 October 2018, the EU Parliament approved **"Distributed ledger technologies and blockchains: building trust with disintermediation"**[30]. Since then, the EU is so far taking actions towards promoting and supporting the development of blockchain related technologies at different levels withing companies and public bodies and in different spheres of the European ecosystem.

Precisely, the Commission has shown its interest towards the development of blockchain technologies through H2020 in the **Work Programme 2020** and backed it up with financial support of around EUR 200 million. Therefore, the European Commission "has been active in setting up Proof of Concepts, Pilot Projects and EU initiatives to explore, test and understand legal, regulatory, policy, research and funding needs related to blockchain and Distributed Ledger Technologies (DLT)" [31].

For better understanding, and considering the budget already allocated for blockchain related projects, the table below shows the distribution of the EU funds per sector (about EUR 180 M of EU funding spent for blockchain, data published as of 26 August 2019[32]):

Sector	Budget per area (%)
Environment	1%
Digital economy/society	2%
Education	3%
e-identity	3%
NGI	4%
Media	4%
Data management	7%
Industrial Technologies	9%
Healthcare	19%
IoT	22%
Cybersecurity	26%

Table 3: Distribution of the EU funds per sector

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31 European Commission, "Investing in blockchain". Retrieved March 23rd, 2020 from https://ec.europa.eu/digital-single-market/en/investing-blockchain
32 EU contribution (approx. figures) = 172 Mio and Total costs = 188,3 Mio. Data retrieved from European Commission, "EU-Funded Projects in Blockchain Technology". Retrieved March 19rd, 2020 from https://ec.europa.eu/digital-single-market/en/news/eu-funded-projects-blockchain-technology

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As can be observed, at EU level and related to blockchain, cybersecurity, IoT, healthcare, industrial technologies and data management are the areas that are addressed/supported most so far. However, it is expected that the percentage of the blockchain implementation scale will be increasing in areas such as environment, education and digital economy, among others.

Following this idea, important contributions, exploration and dissemination are being carried out through ongoing projects. Thus, interesting cases of blockchain related technologies and services (including the explanation of its functionalities) are revealed by the Joint Research Centre and among them projects such as "Chromaway property transactions" (Sweden), "uPort decentralised identity" (Switzerland), "Infrachain governance framework" (Luxembourg) and "Stadjerspas smart vouchers" (Netherlands), among others[33].

This is why blockchain related technologies and services are considered for Europe as mainstream with a "decentralised and collaborative nature" for "exploiting the full scale of the Digital Single Market from the outset" [34].

On the other hand, in strategic terms, with the support of the European Commission, several (pilot) projects were launched that currently are "promoters" of blockchain opportunities in Europe. Below is a brief presentation of each of :

- In February 2018, as a European Parliament pilot project, supported by the European Commission's Directorate General for Communications Networks, Content and Technology (DG CONNECT), the EU Blockchain Observatory and Forum was launched. The main purpose of the **EU Blockchain Observatory and Forum** is to follow up and disseminate blockchain initiatives in Europe (thematic reports and interactive maps) and make recommendations on blockchain related technologies and services [35].

- Another interesting initiative and actor that represents international blockchain industry players at EU level is the **Blockchain for Europe (BC4EU)** whose objective is to "contribute to the debate by supporting European decision makers in their goal to make Blockchain a success" under a "constructive dialogue"[36].

- Finally, it is also worth mentioning the **EU Actions on Cryptocurrencies** and especially on cryptocurrencies regulations thus, on 15 December 2017, the European Council and the European Parliament agreed on new set of rules under the 5th AML Directive[39].

As a result, these and many more forthcoming initiatives at EU level are expected to raise awareness among companies on the importance and opportunities of the blockchain technologies.

35 The EU Blockchain Observatory & Forum. https://www.eublockchainforum.eu/about
36 Blockchain for Europe. https://www.blockchain4europe.eu/about/
37 International Association for Trusted Blockchain Applications (INATBA). https://inatba.org/
38 European Commission, "European countries join Blockchain Partnership". https://ec.europa.eu/digital-single-market/en/news/european-countries-join-blockchain-partnership
39 Crybtobriefing. "Cryptocurrency Regulation in the European Union". https://cryptobriefing.com/cryptocurrency-regulation-european-union/

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3.2 Strategic framework to support and promote blockchain technology in Spain, France and Portugal

3.2.1 Spain

So far, in Spain, there is no specifically defined national strategy for blockchain related technology implementation at company level. However, at national and regional political levels there is high awareness for the digital transformation of the Spanish industry. For this purpose, since 2015, **the General Secretariat for Industry and SMEs have been developing the content of 4.0 Connected Industry Strategy.** Therefore, the main action lines of the Strategy are[40]:

- Awareness and communication.

- Academic and voational training.

- Collaborative environments and platforms.

- Boost to digital enablers.

- Support for the digital evolution of the company.

To achieve measurable results through the above mentioned lines of action, a Connected 4.0 Industry platform was built in order "to boost the digital transformation of the Spanish industry through the joint and coordinated action of all companies in the public and private sector"[41].

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40 https://www.industriaconectada40.gob.es/estrategias-informes/Paginas/informes.aspx
41 https://www.industriaconectada40.gob.es/estrategias-informes/Paginas/informes.aspx

Table 3: Distribution of the EU funds per sector

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In support of what has been mentioned above, 6 programmes were launched in terms of assisting national industrial companies towards digital transformation and improving competitiveness. The table below give a brief description of each of these programmes:

Programme	Brief description
HADA	HADA is an advanced digital platform that was designed by the General Secretariat for Industry and SMEs, and through a questionnaire, allows companies to assess their state of digital maturity. The dimensions that are taken into account, are: market strategy, processes, organisation and human resources, infrastructures and products and services. (See detail here: https://www.industriaconectada40.gob.es/programas-apoyo/Paginas/HADA.aspx).
Activa 4.0 industry	This is an advisory programme that through the diagnosis allows identifying of the digital enablers necessary for the transformation process at company level and established the roadmap for its implementation.(See detail here: https://www.industriaconectada40.gob.es/programmeas-apoyo/Paginas/activa.aspx).
IC4 Support	This is an action that support projects that promote the digital transformation of industrial companies through knowledge, technologies, and innovation. As a result, digitally advanced products and services with added value are created. (See detail here: https://www.industriaconectada40.gob.es/programmeas-apoyo/Paginas/ayudas-IC4.aspx).
12 Challenges of 4.0 industry	This is a programme launched by the Ministry of Industry, Commerce and Tourism (MINCOTUR) and developed by the School of Industrial Organization (EOI) that encoureg innovation by connecting new generation companies, startups, with recognised industrial companies in Spain (See detail here: https://www.industriaconectada40.gob.es/programas-apoyo/Paginas/12-retos-Industria.aspx).
ACTIVA Ciberseguridad	This a pilot programme aimed at SMEs cybersecurity promoted by General Secretariat for Industry and SMEs in the framework of the Connected Industry Strategy 4.0 (See detail here: https://www.industriaconectada40.gob.es/programas-apoyo/Paginas/ACTIVA-Ciberseguridad.aspx).
Business Growth	This is a personalised consulting programme consisting of 50 hours of advice that act on six growth levers: innovation, human resources, operations, digitisation, marketing and commercialization, and finance. (See detail here: https://www.industriaconectada40.gob.es/programas-apoyo/Paginas/crecimiento-empresarial.aspx).

Table 4. Support programmes in the framework of the 4.0 Connected Industry Strategy

However, despite the lack of concrete strategy for the blockchain related technology implementation in Spain, there are initiatives that serve as guidance and assistance and highlights the opportunities and importance of disruptive blockchain technology both at public and private levels.

One of these initiatives is the non-profit Association ALASTRIA created in 2017 as "pioneering reference project in the generation of new models of the digital economy" and in order to "foster the digital economy through the development of decentralized / Blockchain registration technologies" in a Multisectoral Ecosystem environment[42].

It is also worth noting that the philosophy of participating in Alastria is the coopetition. So far, thanks to its network and partners, Alastria has registered about 44 deployed use cases with applications in sectors such as fintech, real estate, transportation and logistics, document management and certification, agrifood, health and education, among others. Also, the networks promoted by Alastria partners are Government Model, Scaleability, Low Transaction Cost, Sustainable operation model, data privacy and use activity and digital identity[43].

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42 ALASTRIA. https://alastria.io/
43 For details see the Alastria Corporate Presentation. https://alastria.io/wp-content/uploads/2020/05/20200520_Alastria-Corporate-presentation_ESP.pdf

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Another initiative that is known as **"the voice of digital industry"** in Spain is AMETIC. During its more than 40 years of experience, AMETIC has been representing the interests of large, medium and small businesses and promoting the synergies between them. The areas in which AMETIC partners work are[44]:

- Digital consumer.

- Innovation.

- Internationalization.

- Markets and digital transformation.

- Regulation.

- Digital talent.

Inside its structure, AMETIC has a Blockchain Commission with the objective to share blockchain related opportunities, knowledge and experiences and supports its development ad dissemination in Spain[45]. Besides, interesting blockchain related technology use cases are described in the catalogue prepared by AMETIC where the activity and main services of its companies can be explored[46].

It is also worth noting the Blockchain Intelligence (BI) that is "catalyst platform of resources and training to respond to the needs of developments in blockchain". Being composed by professionals, the platform provides training services, share knowledge, organize forums and connects globally for a greater scope of use and knowledge of blockchain technology[47].

44 AMETIC. http://ametic.es/es
45 AMETIC. Blockchain Commission. http://ametic.es/es/areas-de-actuacion/agenda-y-transformacion-digital/comision-de-blockchain
46 AMETIC. Blockchain Commission Catalogue. http://ametic.es/es/publicaciones/catalogo-de-empresas-de-la-comision-de-blockchain
47 https://blockchainintelligence.es/nosotros/#

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3.2.2 Strategic framework to support and promote blockchain technology in France

The interest shown by the French public authorities in Blockchain technology is quite recent. Some initiatives and decisions taken in recent years mark the desire to build a real public policy in support of technology. The public authorities are interested in the Blockchain through policies supporting the Industry of the future and not on a dedicated basis. However, France does not hide its great ambitions for this technology applied to different sectors: economy, finance, industry, public administration, etc.

The first French laws concerning Blockchain date back to 2016 and 2017 when a legislative framework was initiated for the use of technology by the financial sector, and more particularly for crowdfunding operations. This legislative framework was quickly extended to other financial instruments (negotiable debt securities for example). The PACTE law passed in 2019 contributes to strengthening regulations by notably developing a legal and fiscal framework for fundraising known as ICOs (Initial Coin Offering) guaranteeing security for issuers of digital assets and investors through the creation of a visa issued by the Autorité des Marchés Financiers.

The main public initiatives have mostly been related to financial and monetary applications of Blockchain technology. However, more recently, it was affirmed that it was "the will of France to become a benchmark in development and regulation" in order to have a "head start" for French companies[48].

The mobilization of French political players, and in particular the Ministry of the Economy, around Blockchain reveals an awareness of the multiple interests of technology for different economic sectors. There is the ambition to promote its development in the service of companies, for example agrifood, to meet the needs for traceability and transparency vis-à-vis consumers[49].

Indeed, the agri-food sector is one of three sectors, along with the construction industry and the energy industry, where the development of Blockchain technology has been considered a priority at the national level. In order to make this ambition a reality, the Blockchain Task Force was launched in July 2019, bringing together "French experts from associations in the private sector, the world of research and administrations, in order to monitor the government's strategy in terms of blockchain, to allow the sharing of experiences on blockchain projects led by public or private actors and to support the structuring of the ecosystem "[50]. The national Blockchain strategy is based on 4 main axes:

- Strengthen the excellence and structuring of French industrial sectors to deploy projects based on distributed ledger technologies,

- Be at the forefront of technological challenges,

- Encourage innovative projects based on distributed ledger technologies,

- Support and secure blockchain project leaders in their questions, particularly legal and regulatory[51].

48 https://www.lesechos.fr/finance-marches/banque-assurances/blockchain-la-france-reve-de-devenir-la-reference-mondiale-1009544
49 https://www.lesechos.fr/industrie-services/conso-distribution/carrefour-rejoint-la-blockchain-alimentaire-dibm-141191
50 https://www.entreprises.gouv.fr/fr/presse/numerique/enjeux/task-force-blockchain
51 https://www.entreprises.gouv.fr/fr/numerique/enjeux/la-strategie-nationale-blockchain

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Delivered in February 2020[52], the first report of the Blockchain Task Force makes 52 main recommendations for the development of Blockchain technology in France, emphasising the need for substantial public funding and support for research and innovation to help businesses and civil society in general to understand this disruptive technology. The submission of the report also provides an opportunity to recall the existence of various national mechanisms that can support initiatives to deploy Blockchain technology:

- *France Expérimentation:* interministerial mechanism allowing an economic actor encountering a difficulty due to a regulatory or legislative standard to remove this blockage through an experimental protocol over a limited period authorising a derogation from the standards in force[53],

- The Fonds pour *l'innovation et l'industrie* of which 4.5 billion euros (DeepTech plan) are dedicated to financing disruptive technologies[54].

Despitethe interest shown in Blockchain technology by the public authorities and the many initiatives taken in this direction, it is still taking time to raise the awareness of manufacturing industry players on the real impact of the adoption of this technology to meet their needs and uses. This is evidenced by the difficulties encountered by the Industry of the Future Alliance, which is struggling to mobilise beyond providers of technological solutions to work within its Blockchain technical committee. As a reminder, the Industry of the Future Alliance, created in 2015, "supports French companies and in particular SMEs in the modernisation of their industrial tools and the transformation of their economic models through new, digital and non-digital technologies". The success of Blockchain will depend on its wide use by players in the manufacturing industry, first involving significant work to demonstrate its usefulness through concrete and reproducible application scenarios.

Thus, Blockchain technology has been at the heart of public technological innovation policies in France for several years, benefiting from the interest of public decision-makers wishing to develop and deploy this technology within companies, particularly industrial ones. Initiatives and mechanisms have been put in place to encourage and support economic players in their approach to adopting Blockchain. However, the French regulatory and legislative framework still needs to be adapted and the availability of massive financing needs to be reinforced. It will also be necessary to pay particular attention to the mobilisation of industrial players who are still not sensitive enough to this technology today.

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52 https://bitcoin.fr/reunion-de-la-task-force-blockchain/
53 https://www.google.com/search?client=firefox-b-d&q=france+exp%C3%A9rimentation
54 https://www.gouvernement.fr/le-fonds-pour-l-innovation

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3.2.3 Strategic framework to support and promote blockchain technology in Portugal

The competitiveness of economies is directly related to their ability to adapt to the constant changes and needs of different markets, with companies' technological skills, namely the degree of innovation of the organisation, its production processes and products, determining affirmation for Portuguese companies in the international markets.

The Portugal's performance related to the most developed economies in the EU has registered a growth trend in national R&D expenditure since 2016. The Portuguese government's objective is to continue and strengthen this path, by reaching a global investment in R&D of 3% of GDP until 2030, with a relative share of 1/3 of public expenditure and 2/3 of private expenditure[55].

Source: Programa Nacional de Reformas

This growth is due to the incorporation of new technologies in production processes, with gains in quality and added value of national products, not only in emerging industries but also in more traditional sectors.

The R&D and Innovation activities led by companies, whether in individual or collaborative projects, have had a very relevant evolution as a total incentive.

Despite this positive evolution, the Portuguese economy still presents some constraints, for example:

- Low levels of productivity and competitiveness, due to a profile of productive specialisation based on industries of low and medium-low technological intensity and weak knowledge intensity, the level of skills of the population and the persistent low levels of investment.

- Low levels of cooperation between entities in the science and innovation system and companies, and knowledge transfer, which are obstacles to the innovation process and to the competitiveness of the productive fabric.

Thus, the measures to be implemented to boost R&D and Innovation are organised into four areas, the objectives of which are:

- Reinforce investment in science and technology, democratising knowledge and innovation and encouraging cooperation with business associations, clusters and companies.

- Renew existing activities through innovation, technological adaptation and the improvement of management skills.

- Promote the creative potential of new companies, new entrepreneurs and new offers.

- Encourage the integration of companies and institutions in international value chains, favoring the internationalisation of knowledge and the Portuguese economy.

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55 https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=6ac404ca-9f41-4d83-ae70-6ffff158803b

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Thus, aiming at the valorisation of national products, through innovation, increased productivity, value creation and the incorporation of technology in the production processes, the Portuguese Government, through Portugal 2020, provided various types of support to companies and entities on scientific and technological development, with emphasis on the following:

a) INTERFACE Programme[56]

The main objective is to transfer technology and knowledge from scientific centers to companies, in order to develop their Research, Development and Innovation (R & D & I) capacities.

The main initiatives of this programme are:

- Support for Technological Interface Centres (entities that establish the link between higher education institutions and companies).

- Certification and support to Competitiveness Clusters.

- Support for the creation and exploration of Collaborative Laboratories, aimed at implementing research and innovation programs, which promote R&D activities, scientific employment, scientific and technological internationalisation.

- Support for the creation and operation of the Suppliers' Club, aimed at integrating SMEs in international value chains, namely in global supplier networks through cooperation with companies with an international dimension that facilitate access to technologies, markets, and skills.

This Programme also includes the valorization of highly qualified human resources, the use of the knowledge generated in favor of innovation, the generation of added value, exports and the internationalisation of companies, as well as their integration in international value chains.

b) Mobilising Programmes[57]

It is important to refer the importance of collaborative and cooperation projects between companies and the scientific system for digitisation and innovation in national production, with emphasis on the Mobilising Programmes due to their structuring nature, for the development of strategic R&D&i projects in cooperation between companies, universities and other research entities.

In 2019, projects with the type of research and technological development (R&TD) in co-promotion and focus on support for R&D&i in areas with the greatest potential for economic valorisation stood out. About 96% of total support to companies is aligned with the national/regional strategy of smart specialisation (ENEI/EREI), namely with the strategy for the Automotive, Aeronautics and Space, Production Technologies and Product and Energy Industries sectors[58].

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56 http://www.programainterface.pt/pt
57 https://www.ani.pt/pt/financiamento/incentivos-financeiros-pt-2020/mobilizadores/
58 https://www.fct.pt/esp_inteligente/index.phtml.en

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c) Industry 4.0[59]

Through the Industry 4.0 initiative, integrated in the National Strategy for the Digitisation of the Economy launched in 2017, the Portuguese Government intends to generate favourable conditions for the development of national industry and services in the new paradigm of the Digital Economy, through a set of measures based on three areas of action[60]:

- Phase I of the Industry 4.0 programme, launched in 2017, was based on priority areas of action: training of human resources; technological cooperation; creation of the start-up I4.0; financing; investment support, creating favourable conditions for investment directed to Industry 4.0; internationalisation and legal and normative adaptation.

- Phase II of the Industry 4.0 program, created to respond to the 4th Industrial Revolution (the digital one), was created with the objective of fulfilling a decade of sustained convergence with the European Union, inscribed in the National Strategy Horizon 2030.

This phase includes a set of **measures based on three areas: Generalise, Empower and Assimilate.**

The measures include the sharing of knowledge, experiences and benefits as a way to stimulate the massive transition to i4.0 through, a tool that allows companies to make a self-diagnosis about their digital maturity - Shif 4.0, by promoting the dialogue between academy and companies, reinforcing the Open Days i4.0 initiative, through the presentation and promotion of good practices, as well as the creation of a network of i4.0 academies.

The new phase of the Industry 4.0 program also provides for a set of measures to promote, facilitate and finance companies' access to experimentation with i4.0 methods and technologies, as well as supporting their scale-up and digital transition, with solutions available for credit requirements

The Incentive Systems available that aim to support the modernisation and innovation of its products, services and business models, making them more competitive in the context of Industry 4.0 and are divided into three types of action:

- **R&D - R&D projects** in cyber-physical systems; Virtualisation and Simulation; Artificial intelligence; Digitisation; Augmented Reality and wearables; Nanotechnology and advanced materials; Energy;

- **Productive innovation** - For Productive Innovation projects in Connectivity; Intelligent production processes; Additive production; intelligent machine; Advanced materials; modular operations; 3D printing; Autonomous robots;

- **Digital Economy** - Digital infrastructure, cloud computing and cyber security; Advanced analytics and AI; User-Centered Design; WCM and CRM - Web Content & Customer Relationship Management; E-Commerce and E-Marketplaces; SEO and SEA - Search Engine Optimization / Advertising Social media, content & mobile Marketing; Web Analytics.

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59 https://www.iapmei.pt/Paginas/Industria-4-0.aspx
60 https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=5476a28b-cb00-4b20-b233-ad888206e1b3

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Technological and Business Innovation Strategy 2018-2030[61], approved by the Resolution of the Council of Ministers 25/2018, constitutes the main reference for the innovation policy for the next decade in Portugal.

The definition of a national strategy aims to generate greater competitiveness of the Portuguese economy and the insertion of companies in international chains, namely through the increase of private expenditure in Research and Development (R&D) and greater selectivity of public expenditure. The valorisation of qualified employment and scientific, intensifying collaboration between companies, especially small and medium-sized enterprises (SMEs), as well as in scientific and technological infrastructures, encouraging the application of the results of R&D activities in new products, processes, organisational models or marketing and directing them to the market by promoting technology-based entrepreneurship and reinforcing incentives, as well as the participation of companies and networks in international dynamics in order to ensure the dissemination of scientific and business results.

Among the main objectives of the Innovation Strategy, the following can be highlighted[62]:

- Achieve a global investment in R&D of 3% by 2030, with a relative share of 1/3 of public expenditure and 2/3 of private expenditure, corresponding to a global investment in R&D of 1.8% of GDP by 2020 (while 1.3% in 2016).

- Achieve a European leadership level of digital skills by 2030, in association with access and use of the internet, as well as market demand, business development and the development of specialized skills.

- Increase exports of goods and services, aiming to achieve a volume of exports equivalent to 50% of GDP in the first half of the next decade, focusing on the performance of the technological balance.

ANI - Agência Nacional de Inovação, SA (ANI), as a company in the state's business sector, will be responsible for developing the guidelines for a 2018-2030 innovation strategy, through actions designed to support and boost technological innovation in Portugal. This will promote the collaboration between entities in the scientific and technological system and the business environment, and will reinforce participation in international programmes by companies and entities in the national scientific and technological system, namely higher education institutions and interface centres, in order to promote their capacities, competences and results of the innovation support policy.

61 https://dre.pt/home/-/dre/114832287/details/maximized
62 https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=6ac404ca-9f41-4d83-ae70-6ffff158803b

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Technological and Business Innovation Strategy 2018-2030 includes the following strategic vectors:

1. Increased investment in research and development

Develop and implement measures and actions that contribute to an increase of 3.5 times private investment in R&D and reinforce qualified employment, with the creation of 25,000 new qualified jobs in the private sector, and double public investment in R&D.

Reinforce mechanisms to encourage the hiring of highly qualified human resources, to improve the efficiency of the system with regard to its use by young innovative companies under the national entrepreneurship strategy. The concept of partnerships for innovation should also be furthered. ANI should contribute to the adoption of new approaches in technological areas such as the digitisation of the economy, the circular economy and energy efficiency, as well as in the coordination or support to sectoral efforts of strategic interest, such as health, space, biotechnology, agriculture, agribusiness or the sea.

2. Entrepreneurship

Stimulate the creation and growth of new companies with strong innovation potential and greater added value, namely, with great potential for creating qualified jobs in Portugal and in collaboration with the Startup Portugal and Industry 4.0 Programs and other sectorial initiatives with an impact on innovation. The link with investment promotion entities and the early detection of projects and companies should be strengthened.

3. Valorisation and transfer of technology

ANI should, with regard to the protection of industrial property, promote the development of the capacity of companies, technology transfer agents (i.e. technology transfer offices, TTOs), interface centres and other institutions, providing training that improves knowledge about these processes or developing centralised support capacity for these institutions.

4. Internationalisation

Facilitate companies' access to emerging markets at international level and the effort to attract foreign direct investment for activities with a strong innovation potential and greater added value, in close collaboration with international partnerships in science and technology, as well as Portugal's participation in large international institutions with the potential to increase the insertion of companies and research and innovation centers in the value chains and to promote the participation of companies, especially small and medium-sized companies, namely through the current Supplier Clubs initiative.

5. Improve the implementation of European structural and investment funds

Improve the application of European Structural and Investment Funds (ESIF) in collaborative projects between companies, interface centres and higher education institutions, including the promotion of highly qualified employment, regarding the design of instruments, evaluation and monitoring.

Reinforce the investment of ESIF in human resources, knowledge and its transfer, namely in scientific employment, R&D projects and advanced training, as well as in the development of digital skills and the e.2030 National Digital Skills Initiative - Portugal INCoDe. 2030[63].

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63 https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=5476a28b-cb00-4b20-b233-ad888206e1b3

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6. Strengthening of Interface Centres

Strengthen the support and training of the network of Interface Centres and Collaborative Laboratories, promoting greater funding, greater collaboration at national level and internationalisation, in a system that guarantees greater stability and allows the mobilisation and evaluation of the contribution of these institutions to the national strategy of innovation. It requires strengthening collaborative work, between the various social partners, in the national and regional context, namely in terms of the business, economic, social and cultural fabric, and the various actors in the science, technology and higher education system, among others through support for the Competitiveness Clusters, as a factor in promoting collaborative work. In this sense, the Interface Programme is particularly relevant.

7. Promotion and enhancement of innovation

The valuation of innovation deserves greater and more systematic dissemination. Promoting the dissemination of scientific results, demonstrating examples, successful cases of creation, development and application of new technologies and which reveal the capacity of national innovation agents (companies, innovation centres, Universities, Researchers) is essential for the respective activities to be more socially valued, attracting more interest from citizens for technological and scientific based activities.

On the other hand, the index of international fame for research and development and innovation should be increased, as a strategic vector for the internationalisation of our companies and the scientific and technological system.

In this sense, the "Born from Knowledge" initiative should be furthered, as an element of the national dissemination strategy and the highlighting of scientific-based entrepreneurship and created by ANI, a national and international dissemination platform for Portuguese projects, technologies and innovation capacities, following the best practices for promoting and boosting tourism in Portugal.

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3.3 Strategic framework to support and promote blockchain technology at regional level

The objective of this section is to briefly highlight the policies and strategies that support and promote blockchain technology at regional level. Thus, most relevant policies, initiatives and strategies that reveal both the level of policymakers' efforts towards promoting blockchain technology through the use of technology(digitisation) and building pathways towards blockchain governance in the Basque Country, Aragon, Aveiro and Auvergne are examined.

Below table below includes a summary of main policies and strategies in support of blockchain development in the above-mentioned regions:

Region	Policies and Strategies that promote the blockchain technology
Basque Country	PCTI2020: Science, Technology and Innovation Plan for the period 2015-2020. "Basque Industry 4.0" Strategy. PCTI2030: Science, Technology and Innovation Plan from 2021 to 2030
Aragon	Industry 4.0 Strategy for Aragon.
Aveiro	PT2020 Digital Demo 4.0 project.
Auvergne	"Industry of the future".

Table 5. Policies and Strategies that promote blockchain technology

Next, details about these strategies, initiatives and the main actors in the four above--mentioned regions are explained.

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3.3.1 Policies and strategies that support the development and implementation of block-chain technology in the Basque Country

In the Basque Country since before the publication of the PCTI2020 - Science, Technology and Innovation Plan for 2015-2020 period, a series of incentives were being applied through aid for the digitisation of companies, there was some aid designed for SMEs and for business groups in order to promote some digital aspects of these entities, but which was limited to certain advances in management issues, tools to aid in company productivity, etc. Following the PCTI2020, the Basque Government begins to order the Strategy and Policies aimed at the so-called Industry 4.0.

The articulation of this PCTI2020 is developed based on three priorities: Excellent Science. Competitive Industries: Promotion of industrial leadership in innovation through greater investment in industrial and enabling technologies (ICTs, more Key Enabling Technologies or KETs, and Space), greater access to capital, and greater support for SMEs. And Social Challenges: Contribution of innovation to the solution of the greatest concerns shared by citizens such as climate change, sustainable transport, sustainability and energy security, food safety, ageing of the population or health.

In addition, the "PCTI Euskadi 2020"64 takes as reference the RIS3 smart specialisation strategy approved by the European Union as a mandatory requirement to access cohesion funds; its Strategic Priorities in the Basque Country and for this period until 2020, are: Advanced Manufacturing, Energy and Biosciences/Health.

It is in the Strategic Priority of Advanced Manufacturing, where the so-called "Basque Industry 4.0" Strategy is framed: Research and development directed towards industrial sectors related to transport, specifically automotive, aeronautics, rail and naval, capital goods and machine tools, and metal. It is a commitment to research aimed at incorporating intelligence into production means and systems, taking advantage of capabilities and emerging technologies in new products and processes, integrating advanced materials into solutions with higher added value or improved processes, the efficiency and sustainability of the resources used and the integration of high added-value services.

Throughout the recent years of development and deployment of this "Basque Industry 4.0" Strategy, a series of initiatives have been developed to help transform the Basque business network through this digital transformation: dissemination and diffusion, various tools to support this transformation and the strengthening of the so-called Basque Network of Science, Technology and Innovation (RVCTI), a set of agents that make up a comprehensive scientific-technological offer to face market inefficiencies and boost innovation and, therefore, need to be provided, regulated or financed, at least partially, by public administrations.

In addition to the efforts in various tasks of social and industrial awareness about the transformation towards Industry 4.0 (for example, a great event that is held every year called "Basque Industry 4.0 The meeting point", which brings together about 1,500 people every year from the industrial world to show, share and learn about the benefits of the transformation towards Industry 4.0) and various support tools, in recent years what we call the Basque Digital Innovation Hub (BDIH) has been developed, fully aligned and coordinated with the European initiative "Digital Innovation Hubs". It is in this BDIH that transforming technologies begin to be ordered in Connected Asset Nodes and advanced manufacturing services.

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64 Estrategia Euskadi 2020. https://www.euskadi.eus/contenidos/enlace/pcti2020_resumen/es_def/adjuntos/pcti_resumen_es.pdf

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Instead of including here a list of activities related to blockchain, this document includes a link in order to have an updated version. https://www.spri.eus/en/basque-industry/, the Industry 4.0 events, and updated BDIH nodes and how they interact with each other.

In the Basque Country, Blockchain technology is considered as a technology within the Node that is called Cybersecurity. The BDIH cybersecurity node is made up of 5 laboratories distributed and connected to each other, all of the members of the BCSC, Basque Cybersecurity Centre, an organisation designated by the Basque Government to promote cybersecurity in the Basque Country whose mission is to promote and develop a culture of cybersecurity among Basque society, dynamise the economic activity related to the application of cybersecurity and strengthen the professional sector.

The laboratories are used to promote entrepreneurship and innovation, with a special focus on smart-grid, automotive, blockchain, product testing/certification projects, etc.

In preparation for the coming years, the Basque Government has already published the new PCTI2030, Science, Technology and Innovation Plan 2021-2030. It includes the RIS3 Strategic Priorities: Smart Industry, Cleaner Energies and Personalised Health. The Basque Government, within the framework of the Intelligent Industry Strategy, will continue to develop the Basque Industry 4.0 strategy, in which the continuous development of the Basque Digital Innovation Hub and its Cybersecurity node is planned. In any case, the Map of base technologies marked in this PCTI2030 includes, within Digital or Virtual Technologies: Artificial Intelligence and Big Data Technologies/Data Science; Predictive and decision-making algorithms, Machine learning, Data Analytics, Artificial Vision, Digital Twin; Internet of Things and 5G Technologies: IoT Connectivity, Digital platforms, Cloud computing; Cybersecurity: BlockChain, Product Cybersecurity, Network Cybersecurity and Cyberphysical Systems: Control algorithms, Actuators, Embedded Electronics, Sensory and Biosensors. As can be seen, Blockchain is included in the research priorities within the Basque Country research plan.

The concordance between these opportunities and the potential actors is set out below:

- **The Aerospace Cluster:** The Basque Aerospace Cluster, HEGAN, aligned with the Basque policies and strategies, has two main challenges where digital transformation and the implementation of technologies such as Blockchain are one of the main topics: Reinforce the Value Chain and Knowledge Development. In recent years the Basque Aerospace Cluster has developed a specific R&D and Innovation Strategic Plan; identifying 6 main topics, 4 of them related to digitisation and the transformation to Industry 4.0: Robotics and Automation, Digital and Connected Plants, Additive Manufacturing and Advanced machining. Blockchain technology will be key in this transformation and digitisation of the aerospace sector.

- **The Construction cluster:** Basque Construction Cluster´s main aim is to promote competitiveness of the sector by means of collaborative innovation projects of its associates. The strategic agenda for 2020-2023 defines five challenges, one of which, Knowledge and Technologies, reflects on the need of incorporating/embedding/including knowledge and cutting-edge technologies in the industry that will improve the competitiveness of the companies in the cluster. In that sense, this are the strategic guidelines that support the development and implementation of blockchain in the construction industry.

- **AFM** - Spanish Association of Machine Tool Manufacturers. Machine Tool Cluster nationwide. This technology is being promoted and led by the AFM itself, and stems from its AFM Connect strategy.

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- **Metal Association:** Sectorial business organisation that groups together the collective of companies from the Bizkaia Iron and Steel industry. Federación Vizcaína de Empresas del Metal (FVEM) is leading the digital transformation of metal companies through several EU initiatives related to Industry 4.0 and smart engineering for improving the competitiveness of SMEs.

- **Basque Energy Cluster:** Sectorial business organisation that groups together the collective of companies from the Bizkaia Iron and Steel industry. FVEM is leading the digital transformation of metal companies through several EU initiatives related to Industry 4.0 and smart engineering for improving the competitiveness of SMEs.

- **GAIA** - Association of Electronic and Information Technology Industries of the Basque Country Cluster Association of Telecommunications. Basque grouping of electronic and information technologies. GAIA reveals that it is promoting an applied transfer action towards the identification of reference cases in the use of ICT, which demonstrate the opportunities that every industry can experience for its evolution towards Industry 4.0. This exercise is a dynamic sample of examples, where companies from different sectors and sizes share their experiences in the application of ICT technologies. Blockchain technologies are perfectly aligned with GAIA's proposals in this area.

- **CyBasque** - Basque Country's cybersecurity cluster. Cybasque is carrying out coordination work on cybersecurity between the different agents in the Basque industry. Among other initiatives, it coordinates the BDIH cybersecurity node, which offers an unbeatable infrastructure to carry out some of the Blockchain activities.

In conclusion, the **Blockchain technology will enable companies** (for example, Machine tools, Energy Distribution, construction, and Aerospace) to:

- **Maximise the added value** of their current industrial products.

- **Optimise the efficiency, availability, interoperability and quality of its resources,** maintenance services, design and production processes.

- **Foster the creation of innovative business models** for its multiple clients and suppliers in the new global digital ecosystem.

Finally, on **1 April 2020, in the Official Bulletin of the Basque Country, the RESOLUTION of 25 March 2020, from the Director General of SPRI - Basque Agency for Business Development, the approval, publication and convocation of the regulatory bases of the Aid Programme "Industria Digitala" 2020** were published.

According to article 6 of this resolution, **blockchain is also included among the eligible actions**. It particularly says: *"The following projects for diagnosis and/or implementation of TEICs will be considered eligible actions: 1. – Sensory, SCADA, servitisation, automation of industrial processes, BIGDATA, Artificial Intelligence, machine learning and blockchain…".*

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3.3.2 Policies and strategies that support the development and implementation of blockchain technology in Aragon

In general, there is no specific proposal in Spain from the Public Administration for the global development of this technology to date, although there are working groups to explore and monitor the possibilities provided by blockchain.

The only exception, the only case of a Spanish Public Entity that has approached blockchain as a strategic pillar, is found in the region of Aragon.

The Government of Aragon has been a pioneer in the application of blockchain for public procurement, developing a new blockchain-based electronic tendering platform with which to manage the contracting of services or public works in a safe and transparent manner. This initiative involves both managing the identity of the contractors and the smart contracts with which to formalise the proposal in question, all with Ethereum as the backdrop. The system's Smart Contracts evaluate the offers, the first step to avoid corruption in this type of contract. In other words, all offers received for public contracts are registered with Blockchain technology. It is a pioneering initiative in Spain and even in the **European Union.**

Aragon is working to be one of the eleven centres specialised in a specific area of blockchain, which are being formed throughout Spain. In fact, the Government of Aragon itself is the only regional authority that has become part of **Alastria**, a National network on blockchain. Alastria promotes the creation of a decentralisedSpanish blockchain map by specialities, so that national and international industry can locate them as nuclei that supply the technology.

In this sense, **ITAINNOVA** plans to launch a laboratory to investigate the combined use of blockchain and IoT (Internet of Things). In fact, experts in blockchain technology see it as ideal for securing the information collected by IoT sensors.

It is also in Aragon that the autonomous Administration has been working for months to design a way to incorporate blockchain into its procedures. It has formed a working group with technicians from various departments to study the use of blockchain in administration, healthcare, education, administrative records, digital identity and citizen participation. Specifically, the working group will address, together with financial entities, the study of the use of blockchain in granting guarantees and endorsements. Another interesting initiative is the strategy of the Government of Aragon for creating an Industrial Blockchain Pole, together with the University of Zaragoza and Itainnova.

With this, the autonomous community is advancing in the formation of a blockchain industrial pole in its territory, together with the University of Zaragoza and ITAINNOVA (Technological Institute of Aragon), to which they want to attract other administrations and companies in the community. Both the university and ITANNOVA have adhered to the agreement between the Aragonese administration and Alastria, together with Aragonese de Services Telematicos (AST) and the Parque Tecnológico Walqa (PTWALQA, Technological Park Walqa (Huesca)).

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In this same community and in a coordinated way, the General Directorate for Industry, SMEs, Commerce and Crafts under the Department of Economy, Industry and Employment has overseen preparing, promoting and coordinating an Industry **4.0 Strategy for Aragon**. A common regional strategy that brings together all the main actors of the Industry 4.0 system in Aragon, as a meeting point and connection for them, offering technical and practical information, resources, tools, examples and points of contact, all with a primary target audience which are the Aragonese companies involved in industrial activity. This initiative is defined in the **"Law of regulation and promotion of the industrial activity of Aragon**, the consolidated text of which was approved by Legislative Decree 3/2013, of 3 December, of the Government of Aragon, and in which Chapter V is dedicated to Industrial Development. The general guidelines and competencies of what the industrial promotion policy in Aragon must mean are established. The development of the industrial sector, innovation and social cohesion are some of its main objectives.

As a consequence of the current organisation of the Autonomous Administration, the Department of Economy, Industry and Employment, through the General Directorate of Industry, SMEs, Commerce and Crafts, is in charge of providing impetus and conducting an Aragonese strategy for Industry 4.0 , **"Aragon Industry 4.0"** *and it assumes the powers in the field of industrial development and SMEs in accordance with the Decree of 5 July 2015, of the Government of Aragon, which modifies the organisation of the Administration of the Autonomous Community of Aragon and competencies are assigned to the Departments. "*

Industry 4.0 or what is called the **4th Industrial Revolution** comes from the hand of the impulse to a generalized digital transformation as well as the joint introduction of a series of technologies in the industry. It´s a Revolution characterized by Internet of things technology (Internet of things or under the acronym IoT), and based on the use of sensors, networks and wireless communications, an increase in the use of increasingly intelligent robots and machinery, as well as improvements in computer systems and massive data analysis ("Big Data") that will mean a disruptive change and a radical transformation in the business, industrial, social-labour, and even cultural environment. Industry 4.0 tries to boost competition from companies and the regional industrial sector, through a far-reaching strategic approach, supported by technological development; capable of generating wealth, employment and social welfare.

In that respect, **Aragon Industry 4.0** Strategy (AI4.0) serves as a guide for the whole industrial sector, guiding, supporting and giving support on public policies in this area; in the same way that it stimulates an effective and efficient cooperation between all relevant stakeholders: industry, technology providers, Government of Aragon and all its Departments and dependent public organisms, research and technological centers, the Aragonese R&D, University, Clusters, Business and Union Organizations, to ensure that this transformation drives the Aragonese industry of high levels of employment and social cohesion in an intelligent, sustainable and inclusive economy.

Aragon Industry 4.0 Strategy is a way to provide a coordination and cooperation mechanism between the Aragonese agents involved in the industrial sector and to give the Aragonese economic fabric and society the instruments, knowledge and skills necessary for the full enjoyment of opportunities. of economic, professional and human development that provides the transformation towards a Connected Industry 4.0.

This strategy not only seeks the **digital transformation of the Aragonese** industrial sector to achieve competitiveness in a sustainable way, but a quality job too.

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Other objectives of this Aragon Industry 4.0 Strategy that support the development and implementation of blockchain technology in Aragon are, in general terms:

- To increase industrial added value and qualified employment by developing the local offer of digital solutions; as well as guaranteeing the knowledge of Industry 4.0 and its associated technologies, promoting the development of an Aragonese offer of digital technology enablers.

- To offer training in digital skills for children and young people, future technicians and professionals (University, VET) appropriate to the expected labour market and retrain workers in digital knowledge.

The Government of Aragon itself defines in specific actions **Annual action plans** together with the Council of **Industry of Aragon**. With reference to Blockchain Technology, the Administration has begun training its employees in blockchain, to modernise the provision of public services and to improve public-private collaboration in public procurement, and to value its contribution to improving transparency, and administration efficiency. The "**Blockchain Ecosystem**" in Aragon aspires to integrate other administrations and private initiatives that want to join too. The difference with what has happened on other occasions is that, with Blockchain, it is the public sector that has promoted this proposal.

How does public procurement through Blockchain work in the Government of Aragon?

In a public bidding process, companies formalise and manage bids in their possession until they are opened and publicly valued, thus guaranteeing that their proposal cannot be filtered, plagiarised or modified once submitted and before it is subject to Weighting by the Autonomous Administration. "Companies register the so-called" electronic footprint "of their offers in a distributed network, which means that this information will be replicated on several nodes (computers) located in different institutions."

The registration of the electronic footprint of the offers guarantees the integrity of the bids and the blockchain system would detect any subsequent change, which would invalidate them.

The operation of the system is intended to be very simple. The objective is that blockchain technology is used without bidders knowing that it is being used, i.e. that it does not create any additional barriers or complications for bidders, especially for small and medium-sized companies.

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3.3.3 Policies and strategies that support the development and implementation of blockchain technology in Aveiro

The adoption of blockchain technology is still at the embryonic stage in much of the world, including Portugal.

In Portugal, Blockchain has been boosted by the Portuguese blockchain association and in various challenges launched by companies or by funding opportunities in the context of domestic and foreign programmes.

The subject has aroused interest and several initiatives to promote it at events such as:

- **Coimbra May 19** - Relevant themes were presented for discussion, namely use cases, legal and regulatory framework, the role of public, private initiatives and strategic guidelines. In the morning, the Assistant Secretary of State for Administrative Modernisation, Mr Luís Goes Pinheiro, made a valuable and elucidative speech regarding administrative modernisation.

- **In April 2019** the first meeting of the Legal Advisory Board - LAB - on Blockchain Legislation and Regulation was held. The project is an initiative of the Portuguese Blockchain Alliance, in partnership with large Law Firms in the country. Among the main objectives of the LAB is the delivery of a White Paper to the Government, with concrete proposals for the dissemination of knowledge about DLT (Distributed Ledger Technologies) in Portugal, clarification of the applicable legislative framework and final regulation, and the taking of positions regarding the potentialities and contributions of Blockchain to economic development in the various areas, involving the interlocutors of each sector.

- **Covilhã, November 2019** - The 8th edition of the Portuguese Initiative of the Internet Governance Forum, with the motto "regaining trust in the Internet". The debate focused around themes such as Internet public policies in national and global contexts, decentralised ledger technologies (DLT), including Blockchain, illegal content on the Internet and behaviour, security and trust in Cyberspace.

At **university level,** there are the first efforts of teaching blockchain curricula units. Funding programmes are also available under several programmes such as PT2020 to fund initiatives to implement Blockchain in several sectors. There are cases for mobility, EMEL project, in energy in which we have the participation of Portuguese companies in European projects.

There are many Portuguese blockchain-based projects that "are coming to market", many derived from other projects or specific challenges.

Banking, insurance, public administration, retail, automatic verification of identities, contracts or other records are some of the areas that can benefit from Blockchain.

In the region (central zone and Lisbon) there have been several activities for the development of industry 4.0. An example of this is the Digital Demo 4.0 project, which sought to encourage the digitisation of creation, production and customer interaction processes, supported by the growing interconnectivity of equipment, solutions and services, through the extensive use of the concepts of architectures and applications of systems and software in the field of the Internet of Things (IoT), together with the incorporation of advanced production technologies, using field demonstration, in relevant environments.

With this project, a strong involvement of the target companies in the validation of the pilot demonstrators was favoured, ensuring that companies have a very detailed image of the technologies developed and their advantages.

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The target companies of this project are the industries within the scope of AIDA - Industrial Association of the District of Aveiro, thus covering the Central and Northern region of the country, to valorise and demonstrate the potential of Industry 4.0. with SMEs to speed up their process of digital transformation.

Digital Demo 4.0 was co-financed by COMPETE 2020 through the Support System for Collective Actions - Transfer of Scientific and Technological Knowledge and ran until the end of January 2020

Several conferences and debates on the theme of industry 4.0 have been held in the central region, with examples such as: The Symposium "Aveiro 4.0 | The Future of Technology, Industry 4.0, Digital Marketing and Innovation", an initiative of AIDA CCI - Chamber of Commerce and Industry of the District of Aveiro, held on 11 July 2019, at the Oliveira de Azeméis Business Centre.

The event brought together around two hundred leaders, managers, entrepreneurs and professionals from companies and national and regional organisations to discuss themes related to "Technology and regional competitiveness", "Industry 4.0 and technologies of the future", "Digital Transformation and the future of marketing" and "Innovation at the service of companies".

These types of actions makes the local business fabric aware of the new technological challenges and what companies can gain from their implementation.

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3.3.4 Policies and strategies that support the development and implementation of blockchain technology in Auvergne

Foreword

(I) It is necessary to say that in terms of territorial organisation, effectively impacting regional policies to support businesses in innovation and digitisation, it is no longer relevant, since the merger of the French regions in 2016, to speak of the Auvergne region but indeed of the Auvergne-Rhône-Alpes region. This merger led to a complete overhaul of industrial policies and strategies applying to the entire territory of the enlarged region. We will see, however, that this enlargement did not prevent the emergence of initiatives and structures on a more local scale in the former administrative territory of Auvergne under the impulse and with the support of metropolitan public authorities.

(II) Blockchain technology remains in France a disruptive technology for many but the deployment of which remains in its infancy. To accentuate its deployment, it is still necessary to explain not only the technology, but also and above all, its purpose and the impacts it can have on industrial systems. In the Auvergne-Rhône-Alpes region, blockchain technology is still included in digitisation and Industry of the Future policies today and is not associated with isolated thinking within regional development schemes.

France initiated in the early 2010s a strategic reflection on its industrial policy and more particularly on the new challenges induced by the development of digital technologies, new industrial organisations, new economic models... In the pressing context of a desire to reindustrialise the French economic apparatus, France has engaged in a strategic reflection since 2013 to identify the industrial priorities in which to invest. This reflection is accompanied by an aggressive industrial reconquest policy aiming to support companies in their Industry of the Future approach and to develop a training offer better suited to the future challenges of the "New Industrial France"[65]. It was in July 2015 that the Industry of the Future Alliance (AIF) was thus created following some prospecting work that led to identification of the different technologies to which investment and resource mobilisation had to turn as a priority. The French approach insists on the multidisciplinary dimension of its vision for the Industry of the Future. Digital technologies are certainly promoted but other levers are also considered: new economic models, training, the place of humans in the factory of the future, circular economy... For this reason the French plan is not called "Industry 4.0" but "Industry of the Future". The main task of the AIF was then "to organise and coordinate, at national level, initiatives, projects and work aimed at modernising and transforming industry in France"[66]. Its action is built around three strategic areas each composed of several working groups combining researchers and industry:

1. SMEs, intermediary companies and sectors transformation
- Promoting the existing technological offer
- Industry of the Future showcases
- Deployment within territories

2. Development and implementation of the technologies of the future and standardisation
- Development of the technological offer of the future
- Standardisation

3. Development of the competencies for tomorrow
- Humans and Industry of the Future

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65 Name of the French government strategy aimed at identifying the challenges and priority industrial sectors:
https://www.gouvernement.fr/action/la-nouvelle-france-industrielle
66 http://www.industrie-dufutur.org/nos-missions/

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These working groups have notably led to the emergence of several major initiatives in terms of approach to the issues of Industry of the future:

- The **Guide to the technologies of Industry of the Future**[67], putting in place a classification by lever, macro-bricks and bricks. Each brick is the subject of an explanatory sheet which highlights the levers of competitiveness and should help a business manager to act quickly. The guide defines the bases of the concept of Industry of the Future and describes the major challenges. It also constitutes a contribution to public support programmes for companies within the framework of Industry of the Future. Finally, this repository is available to research stakeholders to help ensure that their numerous programmes, conducted around the theme of "Industry of the Future", meet the needs of industrialists and the country's economy,.

- The **National Catalogue of Solution Providers** promoting all the companies offering technological solutions capable of initiating the transformation of a company into Industry of the future. The solutions listed are those responding to the technological building blocks identified by the Alliance as being at the heart of the technological offer of the future.

- The **"Osons l'industrie" (Let's deal with industry) initiative,**[68] the main objectives of which are to support industry employees in the changes brought about by digital transformation and to generally improve the image of industry and its trades on the job market. Launched in 2016 in collaboration with many major players in training such as the UIMM (Union of Metallurgical Industries and Trades), IMT (Institute Mines Télécom), Arts et Métiers ParisTech and ONISEP and under the aegis of the CNI (National Industry Council), the work carried out by this structure places humans and their know-how in particular at the heart of the discussions and the answers to be provided.

- The **label "Industry of the Future Showcase"**[69], synonymous with commitment to the process of industry transformation, is awarded to companies that have specifically developed an innovative project for organising their production, most often via digital. A guarantor of national and international visibility, the label makes it possible to bring out the best practices imagined by inspiring and emblematic companies. At the end of 2019, 75 labels were awarded.

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67 http://www.referentiel-idf.org/
68 http://www.industrie-dufutur.org/osons-lindustrie/
69 http://www.industrie-dufutur.org/content/uploads/2017/09/BrochureVitrineIndustrieduFuturMars2020.pdf

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These reflections and actions are then relayed to the regions by platforms, relying on the networks of AIF members, local authorities (especially the Regions), Chambers of Commerce and Industry (CCI), competitiveness clusters and other clusters. The latter two stakeholders ensure coordination between the national and regional levels on questions of Industry of the Future by being as close as possible to businesses and their needs. They are also fully involved in regional industrial development initiatives. In the Auvergne-Rhône-Alpes region, the industrial development policy, aiming to translate more locally the national ambitions defined by the Industry of the future Alliance and the European ambitions expressed by the various S3 platforms, is implemented around 8 areas of excellence (DOMEX) allowing the development of precise sectoral strategies to associate the different scientific, economic and academic actors of the regional ecosystem: Industry of the Future and industrial production, Building and public works, Digital, Health, Agriculture/Agrifood/ForesI, Energy, Mobility and intelligent transport systems and Sport/Mountain/Tourism[70]. These areas of excellence are the result, on the one hand, of the fusion of intelligent specialisation strategies of the former Auvergne and Rhône-Alpes regions and, on the other hand, of exchanges carried out with all the regional players in innovation. They are included in the Regional Scheme for Economic Development, Innovation and Internationalisation (SRDEII) and the Regional Scheme for Higher Education, Research and Innovation (SRESRI), structuring documents for regional economic and scientific action.

Catalysts of this ambition, the 22 competitiveness clusters and other clusters of Auvergne Rhône-Alpes are at the heart of the 8 areas of excellence (DOMEX). Through their actions, the competitiveness clusters and other clusters carry the innovation dimension of the regional plan piloted by the DOMEX Industry of the Future. To this end, the competitiveness clusters concerned (Manufacturing, Chemistry, Plastics, Elastomers, Textiles, Energy, Digital Technologies) have joined together in the form of a collective in order to share a common action plan. This collective is led by CIMES. An illustration of the continuity of State and Regional policies, the deployment of the support plan for 10,000 French SMEs in their transition towards Industry of the Future, which is reflected in the Auvergne-Rhône-Alpes Region by a regional contribution to state funding and which leads to an ambition of 1,726 SMEs to be supported before the end of 2021 by the Ambition Industry of the Future scheme.

The competitiveness clusters and other clusters are also mobilised on the attractiveness and European influence of the Auvergne-Rhône-Alpes region through European projects and their contribution to S3 platforms. These structures are indeed essential relays with the European level participating in fact in the implementation of transnational and transregional reflections led, for example, by EFFRA or the World Manufacturing Forum in the field of manufacturing. European dynamics are a central point of the digital transformation of industrial companies, supported by numerous initiatives - I4MS network, platform 4.0 - aiming to facilitate access to technologies, exchange between partners and the emergence of collaborative projects. The competitiveness clusters and other clusters work closely with the specific structures and devices set up at regional level to support the digital development of companies, by training in new knowledge and skills.

In 2017, the Auvergne-Rhône-Alpes Region announced the creation of the Digital Campus Region in Lyon and which will be operational in September 2020. This place will host research organisations, companies, start-ups, service providers and high-level technologies through pilot industrial platforms with a demonstrative and productive vocation.

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70 https://ambitioneco.auvergnerhonealpes.fr/401-ma-page-2.html

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On the private initiative side, the region is not outdone with Hall 32. Public-private partnership (large groups, SMEs, rectorate, competitiveness cluster, public decision-makers), Hall 32 offers a new approach to training and aims to create an excellence programme to train in new jobs in industry requiring qualified experts. One of the main goals of Hall 32 is to break the negative image of industry and give young people the opportunity to enter rewarding professions. It is just as much a centre of competence, a pilot plant, a place of training as a process lab where students learn by doing.

The development strategy and regional tools can be accompanied by local initiatives and structures serving smaller economic and industrial basins compared to the regional scale. This structuring of development policies enables better application and adaptation of global strategies according to the needs and actors present in each of the territories concerned. In the former regional territory of Auvergne, Clermont Auvergne Métropole is at the head of an important economic pole where digital technology and Industry of the Future are two of the Activity Areas recognised as Strategic (DAS). These strategic and innovative fields of activity bring the jobs of tomorrow, and Clermont Auvergne Métropole is attentive to their development, their dynamism, their attractiveness in a hypercompetitive context at national and international levels. Wishing to fully include higher education, research and innovation as the fundamental pillars of its future, Clermont Auvergne Métropole also adopted on 15 December 2017 a strategic roadmap supporting a long-term territorial vision, implemented in the short term by an operational plan of concrete actions. At industrial level, large-scale projects, collaborative dynamics and the vision carried by the economic sectors present locally are thus encouraged by the multiplication of bridges between the worlds of business and research and the implementation of a reactive and concerted innovation policy with the entire value chain.

An essential sector of the economy which it irrigates transversally, digital technology is notably based within Clermont Auvergne Métropole on a rich and diversified ecosystem of public and private actors. Composed of leaders in the digital economy, security and digital services, many start-ups, VSEs and SMEs collaborate with higher education and research, supported by structuring professional networks (competitiveness clusters such as CIMES, Digital League - cluster present since 2012 and with 60 members in the Clermont area, Clermont Auvergne French Tech) and facilitators (incubators, accelerators Le Bivouac and the Village by CA) at the service of their growth and partnership dialogue.

This public-private link between companies and university/academic research laboratories is a tangible reality in the territory as evidenced by the CAP 20-25 project, labelled I-Site in 2017, which aims to create a research university with high visibility at international level in the west of the Auvergne-Rhône-Alpes region, in addition to the university centres of Lyon and Grenoble. Thanks to the involvement of all stakeholders in the territory - higher education and research, local authorities such as Clermont Auvergne Métropole and the Auvergne-Rhône-Alpes Region, as well as businesses - CAP 20-25 helps to promote excellence in Clermont public research combined with the best of private innovation from major industrial partners, such as Michelin and Limagrain, but also from a dynamic network of SMEs. The I-Site label requires in particular excellence in terms of economic development of research and public-private partnerships; this is the reason why the CIMES competitiveness cluster is strongly involved in I-SITE CAP 20-25 Challenge 2 entitled "Innovative systems and services for transport and production": it is indeed an essential vector for stimulating innovations and collaborative R&D projects between companies and laboratories that contribute upstream to the economic development of the territory.

This initiative to structure the scientific and entrepreneurial ecosystem is not the only one to energise the Clermont area in terms of digital research. In 2016, Le Bivouac was created with the ambition to develop and deploy programmes of excellence to boost supported start-ups by giving them access to privileged areas of experimentation, opening up market opportunities thanks to our partners, and offering high-level structuring expertise. The setting up of the Bivouac strongly participated in the FrenchTech labelling of Clermont Auvergne Métropole recognising its involvement in the digital domain. In 2017, the Digital League excellence cluster was created, uniting more than 500 members, including many digital companies, providing them with an adequate service offer for their growth.

THE DEVELOPMENT OF TECHNOLOGIES IN THE BUSINESS FABRIC

4

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4. THE DEVELOPMENT OF TECHNOLOGIES IN THE BUSINESS FABRIC

4.1 Relevant sectors and areas for the application of blockchain technology at regional level: case of the Basque Country, Aragon, Aveiro and Auvergne

The unique characteristics OF Blockchain have attracted growing interest from industry, demonstrating that its field of application extends beyond cryptocurrency, with examples of applications in many industries, such as control of the trade in blood diamonds[71], improvements in the value chain[72] and maritime logistics or even the music industry revolution[73].

According to Angelis et al.[74], the adoption of BlockChain is promoted by the value it creates for businesses. Four determining factors were identified in his study for the adoption of BlockChain:

a.i.1. The first is the decrease IN the transaction cost, both in the financial sense and with the elimination of the need for a central authority and intermediaries.

a.i.2. The introduction of Smart Contracts (SCs), which allow for the creation of rules of knowledge and establishment of trust between unknown parties. This allows operations/ transactions and integration with other IT systems (Information Technologies) thereby adding value.

a.i.3. The introduction of distributed applications (also referred to as DApps) that allow new parts to be incorporated into the company's functions without direct control of the organisation, reducing organisational barriers to service innovation.

a.i.4. Finally, the adoption of CBs, along with other emerging technologies, such as Artificial Intelligence and the Internet of Things (IoT) could allow higher productivity. The increase in productivity would come through automatic decision systems and reduction of indirect costs of storage systems.

The field of applications is diverse in the regions, among which we will highlight:

Agricultural Sector - The application of this technology in this sector can ensure traceability and improve the transparency and efficiency of agents throughout the chain, from farmers to consumers.

Today, most companies use a database or printed material to store and manage all data related to safety, sustainability and bureaucracy[75]. This structure results in very high operational costs, high potential for corruption or error (human and/or technological). The WHO estimates that one in ten people falls ill every year due to the consumption of contaminated food[76]. There are several cases of use of this technology in this sector, just as there are specific companies focused on each objective. The focus of most companies in this area can be divided into

- Traceability (e.g. Grass Roots and ripe.io)
- Food Supply Chain Optimisation (e.g. Agrichain)
- Transactions (e.g. Agridigital and AdriLedger)
- Crop insurance (e.g. ETHERISC and WorldCover)

71 Gronholt-Pedersen, J. (2018). Maersk, IBM to launch blockchain-based platform for global trade.
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Industrial Sector – For example, the manufacturing industry faces significant challenges, from mass recalls to counterfeit materials. Blockchain can impact the industry in many ways:

- Optimising Component collections: for example, since all parts of the vehicle are linked to a unique VIN (Vehicle Identification Number), only vehicles with those specific parts in a poor state are recovered (e.g. AMO).

- Loyalty-Based Microtransactions: they record all purchases and customer information which then allows them to create and distribute customised marketing materials for a specific customer (e.g. loyal and the DAV).

- Property Transfer: increases the speed and transparency of the transaction process (e.g. in automotive BIGCHAIN).

- Insurance and Warranties: automates the insurance creation or renewal processes, as well as all the user information, from accidents, fines and use of the capital goods (e.g. GEM and One Car Payment).

- Automatic financing: regardless of whether the purchase order is from a company, an individual or a dealer the process is practically automatic, from the transfer of money to the completion of all data for the business (e.g. Mahindra).

- Supply Chain Management: consists of tracking the entire process of materials from the purchase of raw materials to the manufacture of the Capital goods. This ensures that there are no counterfeit materials in the middle of the process (e.g. Vertical Car and Toyota).

Construction Sector – The construction sector is aiming to achieve the digitisation of all the value-chain stakeholders. Despite this aim however, everday problems and headaches still prevail, such as:

- Lack of agility and duplication of administrative procedures

- Image of distrust towards the sector

- Shortage of skilled labour

- Disputes over compliance with construction deadlines

- Lack of traceability of materials, whether for use or to be discharged or discarded

- Low definition of execution projects that imply modifications on site and budget increase

- Drop in professional fees

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The construction industry has set forward on the challenging task of transitioning into a 4.0. digital industry. Construction 4.0 will be the basis for the decarbonisation of housing and building stock and thus the improvement of the quality of life of its inhabitants. Furthermore, the construction industry plays an essential role in planning and urban regeneration, aligned with the niche territories of opportunity of the RIS3.

Public Administration Sector - Some of the benefits mentioned, such as greater transparency, reduction of fraud (parallel business), illicit data sharing, favour the development of applications of extreme importance for public administration, among them:

- Electronic Voting: to prevent the holding of two votes by the same person or simply prevent the falsification of one vote.

- Personal Information Management: allows the management and storage of all citizens' identity.

- Access Control: logical and physical access control to different public services with the possibility of traceability of records.

- Asset Control: implementation of asset control systems at different levels of administration with the possibility of maintaining a life history of the registered assets.

Education - The application of blockchain technology in education aims to provide students and teachers with safer, unchangeable, and easily verifiable records. It is a more efficient way to access records, reduce the administrative burden and reduce the costs associated with these checks.

Through this technology, it is possible to record the entire academic career from primary school to doctorate, as well as to prevent certain people from having the privilege or the possibility of acquiring a diploma without attaining a certain level of education, as in the cases of some politicians that have become known in the media[77].

Health Sector - In the specific case of health, data registration and medical confidentiality are factors put at risk by the traditional method of physical storage in paper format or by the physical storage of digital data. These methods have been feasible for many years, but have always presented the same problems: loss of data, unnecessary performance of exams (often repeated), high waiting time for a consultation or loss of individual medical records and, not least, the leakage of personal information, such as addresses, e-mails, mobile phone and telephone numbers, and even medical diagnoses.

Furthermore, the lack of communication between professionals and even between professionals and patients is a gap in the national health system (the Portuguese one, for example). These gaps can be overcome by introducing a service based on blockchain technology, which will protect data with the proper importance, prevent scandals and leaks and eliminate the distance between the professional and the public plane.

Blockchain has come to solve problems that affect the current system, such as the difficulty and time required for access to certain medical records. This new technology allows doctors, pharmacists and patients themselves to consult all information at any time, as it allows for the creation and sharing of a single database, which is provided by the different specialists in this area. In the end, therefore, there is greater security of data, which can be accessed if necessary and if the patient allows it.

Besides this, another advantage of using Blockchain is that doctors have the possibility of spending more time during the consultation on the patient's care and treatment than in the search for their personal data.

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77 Por que razão Relvas perdeu a licenciatura. URL: https://expresso.pt/sociedade/ 2016-06-30-Por-que-razao-Relvas-perdeu-a-licenciatura

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Media Sector - As in other sectors and with other industries, the advertising sector presents some challenges, either because of the existence of fraudulent ads or because of the difficulty companies have in collecting and sharing information from their clients in order to obtain targeted advertising. With the use of this technology, advertisers can enjoy systems with high transparency and encryption. In addition, companies will be able, by cross-referencing information from their ad views, to adjust advertising to each target audience, saving money and time, thus increasing profitability. In addition to translating into enormous benefits for companies, the use of this technology can also give consumers more peace of mind due to its characteristics, which enable greater data protection.

Energy Sector - As in the telecommunications sector, blockchain technology can help energy production utilities to reduce operating costs and offer new services. The following are some possible areas of impact:

- Financial: The use of smart contracts enables automatic measurements and payments, which can facilitate the creation of platforms for micro-payments and pay-as-you-go payments (e.g. Grid+).

- Marketing and Sales: By registering all user information it will be possible to price and advertise more intelligently, based on the times of greatest consumption.

- Automation: the automation and control of decentralised energy systems and microgrids.

- Smart Grid applications, Measurement and Data Transfer: the creation of applications for mobile devices with the possibility of communication, transmission and data storage. The use of sensors in the network allows the creation of platforms for monitoring and control of consumption within a home or business (e.g. Electron).

- Network Management: the use of blockchain technology can assist in the management of decentralised networks, flexibility services and asset management.

- Security: using the encryption and immutability properties of this technology, all personal user and transaction information is confidential.

- Transparency: this is one of the areas that suffers the greatest impact with the application of the technology, regardless of the sector. In the energy sector, it is no exception simply because it is possible to make all processes transparent and share files in an unchanging and freely accessible way (e.g. Grid Singularity).

Financial Sector - Blockchain technology contributes actively to the daily transformation of the financial sector in several ways. Its main reasons for use as well as its benefits are:

- Fewer intermediaries: by removing intermediaries, transactions are faster and more secure, and they become more easily traceable.

- Mitigation of fraud: since all the information present in the Blockchain cannot be altered, it becomes impossible to tamper with contracts, payments and records of events that have taken place before.

- Smart Contracts: because they are automated, virtually instantly executed and easy to verify, their use drastically reduces legal bureaucracy and allows large financial transactions to be carried out in a simplified manner.

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Gaming Industry - In the gaming industry, blockchain technology has the ability to change the way we interact and experiment with games, as well as offering the ability to create new platforms for trading, buying and selling games or components for them. In addition, Blockchain allows the creation of tangible assets that players have exclusively and stored in a personal wallet. Players have the possibility of controlling both their games and their assets. This is a sector that, for most people, goes unnoticed, but which has enormous dimensions. For example, in 2018, 2.2 billion people played computer games daily, but only a third bought the games legally. According to a report published by Newzoo[78], global gaming revenues in 2018 were around $134.9 billion.

Property Registration - Currently, and in several countries and continents, there is a great lack of information regarding landowners. As has been explained, Blockchain has unique features that can provide better storage and certification of information, as well as increased legal security at low cost. Property records were created as a way of measuring economic wealth at a time when buildings were among the most valuable assets one could own. Today, it can be said that the reality is quite different, as land ownership is considered as a form of economic power, a safeguard against displacement or exploitation and even as a cultural base, especially for isolated communities and indigenous peoples. Land tenure records based on blockchain technology have as their main objectives:

- Storage and verification of deeds.

- The performance of more efficient transactions. Although the focus has been more on the advantages and beneficial consequences of using this technology, the reality is that there are also some difficulties, such as the need to digitise all documentation that is currently on paper or the need for Internet connectivity in remote access places. On the other hand, mapping is perhaps the greatest challenge for the implementation of Blockchain in the property registration sector.

Philanthropy and Humanitarian Aid - Lack of transparency is one of the reasons that make donation and aid difficult since it causes donors a great lack of trust in the use of funds. According to a study by Fidelity Charitable, 41% of donors say they have changed their donations because of the welcome increase in information about their applicability and effectiveness[79]. Blockchain has the potential to transform charitable donations and the distribution of humanitarian aid[80,81]:

- increasing transparency;

- reducing costs through disintermediation;

- enabling new mechanisms for monitoring and tracking impact. One of the main advantages of using this technology for philanthropy or humanitarian aid is that it allows a donation to be tracked at each stage, from donor to recipient, and to record each action taken by each intermediary.

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78 Newzoo Cuts Global Games Forecast for 2018 to $134.9 Billion; Lower Mobile Growth Partially Offset by Very Strong Growth in Console Segment. URL: https://newzoo.com/insights/articles/newzoo-cuts-global-games-forecast-for-2018-to-134-9-billion/.
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80 Michael Pisa and Matt Juden. Blockchain and Economic Development: Hype vs. Reality. page 49
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Supply Chain for Blockchain - One of the reasons why the transfer and availability of information is reduced is the use of outdated software that does not consider modern problems such as product counterfeiting. With the requirements to be changed, it is often up to the companies to implement new technologies to satisfy them. The intrinsic properties of blockchain technology allow, for example:

- Fewer human errors: with the possibility of automating the inputs that were previously entered manually by using IoT and/or other automated processes.

- Greater security in data transfer. All data is encrypted and unchangeable, which makes it easier to detect fraud attempts on the network.

- Increased traceability: whether of products, information or errors, technology makes it possible to improve all traceability within the system.

- Increased consumer confidence: the consumer, by having the possibility of accessing all the information about the product, creates, in a natural way, a stronger connection with the vendor.

- Cost reduction: through the possibility of making all payments without the presence of third parties or with automatic information exchanges.

The most important and significant features to consider in a supply chain, so that the quality of its service is not questioned, are:

- Speed of delivery: this is undoubtedly one of the main focuses, since the sooner the product is delivered, the sooner the customer can satisfy their needs. Regardless of whether the customer only wants to satisfy their needs one week after ordering the product or has a certain urgency, the sooner the delivery is completed, the better the customer/seller relationship will be. This applies not only to the end customer, but also to any company that supplies products and/or services to other companies, whether in the role of supplier, manufacturer or distributor.

- Traceability: throughout the supply chain, products undergo many changes: some are lost, others damaged, falsified or even not even registered. The fact that a lot of information about the manufacture and transport of products is neither controlled nor registered leads to great distrust on the part of the customer. Moreover, this lack of control means that the safety of many products is not guaranteed (e.g. sensitive food products or pharmaceutical products which easily lose their essential properties when exposed to inappropriate temperatures) or the health of end customers is endangered. It is essential for these reasons that it is justified that all products, whatever the industry, should be traced from their origin to their delivery to the customer, including the recording of all transport and processing that has taken place.

- Data Transfers: the transfer of data within a company or to an external entity is often questioned due to the format of specific documents, software and protocols. All of this is because companies or even internal departments do not share the same platform, which often leads to unnecessary (un)avoidable manual work.

- Security: this is perhaps one of the most important points that companies are most concerned about. Information in a supply chain is highly confidential and must be controlled so that only trusted entities can have access to it. Due to competition between companies, a simple detail about a product to be launched can translate into losses of millions of euros. This is another reason why much of the information must be secure.

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4.1.1 Relevant sectors in the Basque Country

As can be seen, industry is a clear beneficiary of digitisation offering a great opportunity for transformation and evolution, assuming a guarantee of growth, employment, competitiveness and prosperity due to the multiplier effect that industry has in other sectors and areas such as research or the development of technology-based services.

The new knowledge and advances within the framework of Blockchain Technologies will not only serve to achieve the individual objectives of Capital goods manufacturers, but to exert a driving effect on their entire industrial sector, and by extension on the Basque economy, contributing to its internationalisation. In this sense, it is worth mentioning that the Basque economy continues to be closely linked to the evolution of industrial activity as a key factor in guaranteeing sustained growth and generating employment.

As stated, Blockchain technology could drive and synthesise the knowledge of Capital Goods Manufacturers and information technology domains. On the one hand, it should serve for a much broader and more active commercialisation of goods manufacturers with better routines, which will lead, above all, to a lower cost associated with the sale. But more importantly, it offers them the possibility of focusing on their area of knowledge, leaving other developers to integrate services or benefits not directly related to it.

An example of this would be the creation of a new communication protocol or the introduction of an alarm management application, with a great software development content that should be subcontracted individually by each manufacturer. With the Blockchain platform, the work would tend to fall to one or more independent developers who would compete to market their products and the end user would decide at their discretion.

Once the platform is established, its very dimension can attract other actors to develop other types of applications. The truth is that the end result is an economic environment in which service and application providers, from the IT environment or others, may be attracted to a simple marketing system based on blockchain, a market that is much larger than the one they dream of. Besides, the low-cost portability conditions will guarantee the investments made. For example, a tool manufacturer can develop a calculator-type application that advises the machining conditions (heat, feed) for a given material. This calculator could be commercialised and on the Blockchain platform would be suitable for any user of machine tools with access to it.

This cross pollination between these two very diverse worlds ensures a diversification of the world of the industry sector and communication technologies and allows the updating of goods produced in the Basque Country to compete under equal technological conditions with large manufacturers. The following functionalities could be strategically affected by Blockchain technology:

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- **Maintenance**

The maintenance of the machines after the warranty period ends depends on many aspects: the customer (who may have a SAT department, an external company that does the maintenance or who contacts the distributor or the manufacturer in the event of an incident), the dealer and manufacturer (who may have a maintenance department or company, who can do factory maintenance or have local technicians).

Connection to the machine would allow better care of the machine. The manufacturer could anticipate cases of machine stoppage (in series production companies these are emergency situations) and plan the intervention appropriately. The state of the machine would be known globally and not only in the event of a breakdown.

Maintenance, as it is currently carried out, involves a budget with great variation from one year to the next (from 3 to 8% of turnover). By establishing maintenance contracts, based on the data provided by the machine itself, minimum monthly billing values could be established (which would be added to the current ones) to which any unforeseen breakdowns would be added but which, with the highest Knowledge generated by the available data, could be valued in the medium term. On top of that, by the possibility of maintaining monitoring, the provider has access to the customer to offer other services and even new goods.

- **Warranty**

Even when clearly specifying the terms of the warranty, discussions take place because the purchaser of the goods can suffer damage, due to an improper use of the programming, the working regimes, inadequate maintenance or incorrect integration of the machine in work cell. All these factors make it necessary to have a repository of information on how work has been done and what circumstances have occurred during the active period of the acquired product, it can identify end-user malpractice or system malfunctions not detected in previous phases. Therefore, the need to control the operation of the product in the warranty phase is of vital importance to minimise interventions and disagreements that may arise with the end customer.

Regarding the warranty period of the product, three different elements are distinguished:

- The warranty period usually starts from the time of acceptance by the customer at its facilities.

- Previously, acceptance was made by the customer at the manufacturer's facilities, where anomalies, undefined operations and product performance were detected with respect to surface, geometric qualities or cycle times. Between the customer acceptance at each of the manufacturers and the delivery of the goods, these points were corrected, for final acceptance.

- Component warranty: there are critical components that have a different warranty period than the product itself. Either because the component itself is critical and ensures a longer period of operation, or because the component has a specific warranty on the purchase by the manufacturer (example: numerical controls warranty).

- Warranty for the product itself: this warranty is agreed with the customer, although it is generally 2 years. During that time, the management of disputes is currently nothing more than a tug of war between the two parties, which is either supported by obvious data or is generally resolved with a specific agreement between the parties.

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In complex acquisitions, depending on the technology of the machine and the size of the company in which it is installed, companies rely on external engineering or contact the supplier to develop the programs and improve the quality of the parts or reduce the production times.

At this point, the manufacturer has more comprehensive information on the capabilities of the machine and is possibly the most suitable partner for the customer. On many occasions the customer looks for support companies that are closer in order to have a better post-delivery service. The possibility of having process monitoring technologies would allow the manufacturer's attitude to become more proactive, being able to contact the customer, proposing modifications and improvements based on actual production data, which would allow the machine to be adapted to its way of working. There will be a win-win strategy reflected in a smart contract where the less repairs are needed, the more profitable the collaboration.

- **Productivity and Quality**

Recent consultations on Productivity, Quality and Maintenance based on manufacturing data have been detected by the project consortium. These are variants on the OEE (Overall Equipment Effectiveness) concept, which is usually functionally defined as the OEE product = performance x quality x availability, and which in practice is usually difficult to define. In any case, what arises is not only how to measure the "use" of the product, but also how to articulate payment methods around said use. There are two parameters quite representative of any modality of Smart Contracts:

- Machine availability: these requirements are already being detected in EDM operations with reference customers in the Turbine component manufacturing sector, for example. Therefore, it seems logical to expect that payment for availability or any contract variant associated with availability ends up being one of the digital business possibilities that requires technology to generate security and transparency in the data chain that will condition the payment service.

- Intensity of machine use: on the same line is the case of contracts for maintenance plans, which when they are intended to refer to product use data, require a concept that characterises the type of use. In this case, the parameter "intensity of use" is used.

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4.1.2 Aragon relevant sectors

Aragon Autonomous community is making progress in the formation of a blockchain industrial pole in its territory, together with the University of Zaragoza and ITAINNOVA (Aragon Institute of Technology), to which they want to attract other administrations and companies in the community. Both, Zaragoza University and ITAINNOVA have adhered to the agreement between the Aragonese administration and Alastria, together with Aragonese de Servicios Telemáticos (AST) and the Walqa Technology Park (PTWALQA).

Aragon is working to be one of the eleven centers specialized in a specific area of blockchain, which are being formed throughout Spain.

Alastria promotes the creation of a decentralized Spanish blockchain map by specialties, so that the national and international industry can locate them as technology providers.

In this sense, ITAINNOVA plans to launch a laboratory to investigate the combined use of blockchain and IoT (Internet of things). In fact, experts in block technology see it as ideal for securing the information collected by IoT sensors.

One of the key sectors and in which Aragon stands out in the development and implementation of Blockchain is the **public sector** and above all as a benchmark for contracting and public tenders through Blockchain technology.

Aragon with the General Directorate of Contracting of the Government of Aragon has launched a project to carry out blockchain contracting. The result will be to record the offers received for public contracts with this technology.

Work is also being done on the development of applications to use the blockchain as a system for connecting databases between public administrations, facilitating their interoperability.

Also a sector for which Aragón is committed is the **Construction sector**

There are already several blockchain initiatives in construction, which shows that the digital transformation of the sector is already unstoppable and that there is a firm commitment to it.

The true potential of the blockchain for construction lies in the so-called Smart Contracts that allow, among other things, the automation of processes. These 'Smart Contracts' are computer programs that run automatically on a blockchain network when a series of conditions previously agreed between the affected parties are met. In this way, actions can be automated without the supervision of a third party and providing said transaction with transparency, traceability and immutability.

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Among other advantages:

• Disintermediation to improve the efficiency of processes.

• Traceability and transparency in changes or decision making.

• Single vision and synchronized data for the entire value chain.

• Information reliability by building a single source of truth.

ITAINNOVA in Aragón addresses projects in this sector integrating Blockchain with other technologies such as the implementation of solutions with IoT in distributed ledger technologies (DLTs) such as IOTA or the application of Artificial Intelligence on distributed networks.

In **the Industrial sector,** to improve the traceability of processes, especially in the **automotive sector,** and it is being developed to promote the development of autonomous vehicles. Blockchain could facilitate data integration, thus allowing the creation of an ecosystem of autonomous vehicles and reducing risk in driving, and allowing the connection between manufacturers and vehicles.

The **Industrial environment** enhances the automation of maintenance processes; combining Blockchain and IOT technology.

Logistics sector and supply chain: there are several projects that join forces in the application of blockchain technology to have information in real time, and plan the production chain more effectively. In this sector, identity certification is sought to guarantee the legitimacy, origin and authorship of documents and   wby integrating blockchain in Wallet ID technology (digital identity), for the development and management of the sovereign identity of users against information systems and entity.

The logistics sector is going to be one of the areas that will benefit the most, because cargo can be managed through a secure network where everything is connected, thanks to transparency it will be possible to know the real-time status of the transported or very valuable information such as who has carried out the transport, at what temperature has it been maintained, the treatments have been carried out etc.

Wine industry and food sector: Work is being done on projects to improve traceability in wine production.

There is a project called Fitotraza with some wineries in Cariñena, which work to control the use of phytosanitary products in agricultural operations with blockchain.

The **agricultural and agri-food sector,** key in Aragon, is positioned as a sector to take into account in the digital transformation and in which Blockchain will make it become one of the great allies of this "Smart Agriculture". Being able to have data on crops or their needs in real time and being able to identify / prevent problems in a much more efficient way are some examples of applications in the primary sector.

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4.1.3 Aveiro relevant sectors

Portugal was classified as the 12th most innovative country in the European Union, after climbing six places compared to its position in the 2019 edition of the European Innovation Scoreboard. Portugal rose in the 'ranking' of the European Commission's annual publication in terms of innovation and reached its best classification ever, now being considered a "strongly innovative" country, joining the group of countries that includes Belgium, Germany, Austria, Ireland, France and Estonia.

Portugal's good results over time reflect the increase in the innovation capacity of companies, R&D (Research and Development) entities and most actors in the National Innovation System, including public entities that support and promote R&D and for innovation. Portugal stands out for the second consecutive year as a leader in one of the dimensions of the ranking, "innovation in small and medium-sized enterprises (SMEs)", taking into account indicators that express the percentage of these companies with product/process innovation, marketing/organisational and the percentage of innovative SMEs that collaborate with other SMEs. This important component, which needs to be furthered and valued economically, enhances what are considered good basic conditions for innovation, especially in terms of the attractiveness and internationalisation of the research system and broadband penetration, indicators in which Portugal is above average in the EU [European Union].

The Aveiro region is characterised by a strong business density, strong economic dynamism and a very heterogeneous manufacturing industry, especially relevant are metalworking, chemical industry, agribusiness, automobiles and their components, two-wheel industry, non-metallic minerals (ceramics), electrical equipment, as the most representative. It is a territory where we can find not only several national companies but also production units of important multinationals, with which it is interesting to provide connections and synergies that can respond to the requirements and technological levels, innovation and quality required, in a context of a changing paradigm of economic development.

Alongside the commitment to modernisation, innovation and technology, it is important to develop business initiatives that respond to new challenges and contexts and that can contribute to boosting innovation and increasing productivity and business competitiveness in the region.

The data demonstrates companies' ability to adapt and succeed. Even in an unfavourable context, the region's manufacturing industry and its most representative sectors were able to reinforce their competitiveness, namely through the diversification of products and services, adapting to this new reality, through innovative solutions. The companies showed themselves willing to seek more adjusted answers to the difficulties that the economy presented, they were able to mobilise, make use of their know-how, their recognised competences, take advantage of the knowledge and support to R&D and research and knowledge centres about the region, in favour of its competitiveness.

This interpretation is confirmed by the main regional economic indicators, which prove that the number of companies has shown to be stable and the number of personnel employed in manufacturing companies has recorded an increase. Turnover has also grown (in 2017, 14.5%), together with exports (7.2% in 2018).

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The strategic lines of economic development in the region are based, therefore, on the know-how of its people with regard to industrial activities, as well as on its entrepreneurial dynamism, supporting the transformation or evolution of "traditional" sectors towards activities with greater integration of technology and knowledge, capable of generating greater added value.

Innovation, technological capacity and the qualification of workers are pointed out as the main competitiveness factors across all sectors.

For this, the fruitful and virtuous relationship with the regional scientific and technological system has proved crucial, where, of course, the role of the University of Aveiro stands out. The University has several centres in the Region, since its training offer has been extended to innovative areas such as the Environment, Industrial Management, Materials, Industrial Chemistry and New Technologies, contributing to raising the qualification of human resources and a greater appetite for the development of innovative and research activities in areas decisive for business competitiveness.

In terms of innovation, it is worth highlighting the enormous capacity of some companies of greater importance and dimension, which have created leverage effects throughout the local supply chains, endowing the region with enormous capacity.

The companies in the Aveiro region carry out innovation activities, combining European and global technological innovations with their own innovations; the changes in the conditions of competitiveness at global level have become decisive.

This type of activity includes those aimed at product and process innovation, organisational innovation and innovation in the commercial, marketing and distribution areas. The data also indicates that in investments in innovation, namely those in the region's industry, an integrated and independent technological modernisation model is underlying, in most cases, aimed at improving the technological level of equipment, acquisition and development of new technologies and valuing intangible innovation factors, including valuing human resources, strengthening technical assistance capacity and strengthening customer/supplier relationships.

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Activity Sector	Competitiveness factors
Automotive components	Implementation of effective quality systems, worker qualifications, up-to-date equipment and technologies and sufficient size to respond to orders that require high quality and short delivery time
Wood and furniture	Design innovation, technological development, knowledge of the markets and their requirements and the ability to adapt to those markets
Pottery	High quality individualised products, own brand, niche orientation, small production, flexibility, specialised human resources in design and marketing, implementation of effective quality systems and use of technologically updated equipment
Two-wheeled vehicles	Manufacture of innovative and non-polluting products, provision of technical assistance and replacement of components, parts and accessories and adequate knowledge of the markets and adaptation of the products to the requirements and standards of each market
Dairy products	Technological and innovative capacity, identifica-tion innovative products, own brands and in the certification of companies and products by international quality systems
Metalworking	Own brands, innovative products that follow market trends, use of niche markets that use products with great added value, updated technologies, implementation of effective quality systems, participation in emerging markets
Moulds	Technological capacity, qualified human resources, implementation of effective quality systems, productive flexibility for the manufacture of moulds for small series and compliance with delivery deadlines and other negotiated conditions
Electrical, electronic, energy and telecommunications	Implementation and certification of adequate quality systems, knowledge of the markets and the standards required in each market and good qualifications of human resources

Table 6. Sectoral Competitiveness factors

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It is also worth highlighting the commitment to innovation and the attraction of units from important national and international companies, which has resulted not only in the qualification of the sectors that characterised the region, but also in the rise of emerging sectors such as ICET (Information, Communication and Electronics Technologies), which due to their comprehensive and transverse nature, has had (and will continue to have) an increasing contribution to the qualification and competitiveness of the entire economic fabric, as well as in the potentiation of new opportunities arising in the broader context resulting from the Sea Economy concept.

Blockchain is an emergent technology, and most of the applications are in proof of concept validation. Besides technological issues, the still legal and operative process needs improvements. So, the potential applications taking into account the identified sectors are:

Activity Sector	BC Potential application
Automotive components	Automobile components traceability.Tracking automobile components and assure quality (avoid Falke products)
Wood and furniture	
Pottery	
Two-wheeled vehicles	Product traceability and exchange information with external suppliers. Perform transactions with external suppliers. Use of BC in the supply chain to improve security, process and data exchange.
Dairy products	
Metalworking	
Moulds	Traceability of products. Perform transactions with external suppliers. Use of BC in the supply chain to improve security, process and data exchange.
Electrical, electronic, energy and telecommunications	In the energy sector, several challenges raised where BC can handle decentralized energy transactions, protect transactions. Smart contracts allow automatic energy transactions without central supervision

Table 7. Sectoral BC Potential application

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4.1.4 Relevant sectors in Auvergne

As the leading region for French manufacturing, Auvergne-Rhône-Alpes has a rich and very diverse industrial sector. Manufacturing is transverse to all regional sectors by providing the integrated solutions necessary for business development and making the link between digital technology suppliers and industrial end users.. CIMES, the regional competitiveness cluster dedicated to manufacturing, coordinates the Collective of competitiveness clusters for Industry of the Future in Auvergne-Rhône-Alpes, bringing together players from all sectors. This action underlines the necessary nature of the work between the industrial sectors on the subject of Industry of the Future and Blockchain technology can prove to be an interesting solution to respond in an adapted way to the new emerging needs, in particular to the needs of exchanges and data traceability imposed by the development of intelligent manufacturing solutions such as mechatronics, robotics/cobotics, digital for production equipment and maintenance…

Agriculture/Agrifood

Auvergne-Rhône-Alpes is one of the French regions where the agriculture sector is one of the most important. The regional high-quality agricultural products often benefit from controlled appellations implying a strict control of the origin of raw materials. Meat production is also an essential sector of the region. Major agricultural contractors are present such as Limagrain. The region is also well involved in the logic of precision agriculture benefiting from a network of providers of various solutions (sensors, robotics, autonomous vehicle, etc.). This innovative agriculture requires the collection and processing of numerous data (climate, yield, soil quality, water quality, pH, etc.), often in real time, to adapt and optimize production. Agricultural production is developing a network of players in the agrifood sector that is large and efficient. Agrifood companies are present in large numbers on the regional territory.

Benefits of using Blockchain technology: traceability of raw materials "from the farm to the fork", better transparency/availability of data, improvement in the targeting accuracy of defective products during product takeovers, smart contract…

Additive manufacturing

Auvergne-Rhône-Alpes is one of the pioneering French regions in additive (polymer and metallic) manufacturing technology. The ecosystem of companies engaged in this technology is large and has great potential. Michelin, based in Clermont-Ferrand, got involved very early in metal additive manufacturing, seeing it as an interesting breakthrough technology for its activity, in particular in the design of moulds that are impossible to produce with traditional machining techniques. Much more than just physical manufacturing, additive manufacturing is above all a system for exchanging files and data. More and more companies are interested in it and trade volumes, often confidential in strategic and highly competitive sectors, are increasing significantly, requiring a reliable and sound system.

Benefits of using Blockchain technology: security for the transmission of digital files, better protection of intellectual property (formerly based on drawings, physical parts, etc.) and licence management, benefit of open source for a collaborative approach to files, progress in the use of additive manufacturing on a larger scale by coordinating printers.[82]

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82 https://www.a3dm-magazine.fr/magazine/toutes-industries/blockchain-fabrication-additive-impression-technologie

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Autonomous mobility

The autonomy of vehicles and systems for moving goods and people in general has been a significant trend for several years now and tends to intensify with the development of car-sharing solutions and autonomous personal and collective vehicles. These trends imply a new relationship between the service provider and the consumer, all this digitally.

The IMOBS3 laboratory of excellence "Innovative Mobility: Smart and Sustainable Solutions" located in Clermont-Ferrand aims to develop efficient technological bricks for innovative mobility of people, goods and machines[83]. Backed by university establishments and laboratories, it is a reference center for intelligent mobility. With several test platforms, the IMOBS3 laboratory is developing innovative solutions for urban vehicles as well as vehicles "in the wild" (agricultural robot).

Benefits of using Blockchain technology: customer identity management and pooling of customer data, new secure payment solutions, smart contract, better vehicle monitoring and maintenance[84]

Aeronautics

The aircraft industry in Auvergne-Rhône-Alpes is an extremely important economic sector with several billion euros in turnover and a great supplier of jobs throughout the territory. As a sector subject to numerous changes, notably relating to its environmental impact, the aircraft industry must be at the forefront of innovation involving all actors in the value chain, from the suppliers of parts to the operating companies. More than 300 regional companies work for the aerospace sector, including major clients (Aubert & Duval, Constellium, NTN SNR, etc.) as well as numerous subcontractors (INOPROD, M-Tecks, etc.) and develop innovative solutions to meet current challenges (innovative materials and processes, advanced embedded systems, improved maintenance, etc.).

The aircraft industry nevertheless remains very vertical and has a very top-down digital continuity strategy with tools imposed by aircraft manufacturers and first-rank equipment manufacturers. There is still little room for introducing other tools or protocols without co-opting sector heads. However, for several years now, tools such as Air collab have introduced a new way of collaborating between actors in the sector with more security and efficiency[85].

Benefits of using Blockchain technology: traceability of parts and components, reduction of costs and delivery times of parts and components, securing of passenger data (rapidly expanding), securing of GPS systems.

Health

The potential of Blockchain technology in the sector is huge, especially regarding the management of millions of sensitive patient's data. The current system, although partly digital, is still too inefficient and time consuming. Relations with reimbursement bodies and insurance companies can be complicated and supporting documents difficult to pass on. However, initiatives to implement Blockchain technology to meet the needs of the healthcare sector have been developed. For example, the company be-almerys, located in Clermont-Ferrand (Auvergne), participated in the European project MyHealthMyData developing a blockchain-based solution for the protection of personal data.

Benefits of using Blockchain technology: better management of personal data, drug traceability, automation of reimbursements, better access to data for health services (especially in emergencies) ...

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83 http://www.imobs3.uca.fr/index.php/fr/
84 https://mbamci.com/tendances-futur-mobilite-data-vehicules-autonomes-blockchain/
85 https://boostaerospace.com/aircollab/

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Energy

Auvergne-Rhône-Alpes is one of the most energy-producing regions in France, distinguishing three main types of energy production sectors: the conventional sector which includes nuclear and thermal power plants, the renewable energy sector thermal (wood energy, heat pumps, solar, thermal recovery of waste and biogas ...) and the renewable electrical energy sector (hydraulic, wind, photovoltaic, electric recovery of waste and biogas ...). Auvergne-Rhône-Alpes is one of the French regions where the development of renewable energy production sectors is the most dynamic (notably thanks to its hydraulic capacity).

Benefits of using Blockchain technology: certifying the origin of the energy resource, allowing the personalization of energy mixes for each consumer, facilitating the development of local production and consumption loops (microgrid), improving monitoring in real time of consumption to adapt the need to the demand...

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4.2 Developers, start-ups and beneficiaries of blockchain technologies

The aim of this section is to present the ecosystems that exist in blockchain technologies in the regions of Basque Country, Aragon, Aveiro and Auvergne in terms of developers, start-ups and beneficiaries of blockchain technologies.

4.2.1 Developers, start-ups and beneficiaries of blockchain technologies in The Basque Country

The objective of this section is to briefly present main developers and beneficiaries of blockchain technologies in the Basque Country. For these purposes, as an interesting reference in terms of gathered initiatives in the Basque Country and throughout Spain serves the presentation performed by AMETIC[86].

Although the purpose of this section is to present the initiatives (both in private and public sectors) that employ blockchain related technology, a couple of words about AMETIC are provided, however.

AMETIC is an organisation that for more than 40 years has represented the interests of the technological and digital sector in Spain with respect to different institutions and has styled itself as "the voice of digital industry". The members of AMETIC are SMEs and large companies in digital services, IT, telecommunications, electronics, and related areas[87].

Moving on to the subject of this section, in the Basque Country a very well-known developer of blockchain technology is **Tecnalia Research & Innovation Foundation** where the "Cybersecurity & Safety" research group focuses on logical and functional cybersecurity for computers, networks and data security, among others. More linked to blockchain related technology is the research area centred on Distributed Ledger Technologies[88].

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86 AMETIC. "AMETIC Comisión de Blockchain. Catálogo de empresas". https://ametic.es/sites/default/files//catalogo_blockchain_def_enero2020.pdf
87 AMETIC. www.ametic.es
88 AMETIC. "AMETIC Comisión de Blockchain. Catálogo de empresas". https://ametic.es/sites/default/files//catalogo_blockchain_def_enero2020.pdf

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Taking into consideration the TECNALIA applied research focus, the main related products it develops are private blockchain, cryptography, security intelligence, smart contracts, security in mobile phones, etc[89].

Another developer is **HAZI**, which is a Basque Country instrument, the purpose of which is "to boost the competitiveness and sustainability of the food value chain and the rural and coastal environment of the Basque Country"[90].

HAZI is the company that certificates the quality of Agri-food products from the EUSKO LABEL brand. Linked to blockchain technology, HAZI led the project called **"Blockchain for beef traceability"** the aim of which is the "traceability of meat throughout the entire chain of production and sale of beef in butchers". Here TECNALIA have participated as specialist and adviser in blockchain technology[91].

Another interesting case of blockchain application in industry is "Analysis, development and implementation of a blockchain solution for Basque Government Contractor Registration" launched by EJIE (Eusko Jaurlaritzaren Informatika Elkartea)[92].

The project **"EUSKATE - New technologies of interoperability and collaborative coordination based on Blockchain for the collaborative coordination of the industries of the Basque Country" have gathered 9 entities such as: IZERTIS, Advanced Manufacturing Technologies (AFM), Royde, Gashor Equipos de Planificación, Ibermatica, Dominion, Grupo Ionsolar Aer, Tecnalia and Instituto Ibermatica de Innovación(I3b)**. The objective of the project is the "generation of new knowledge based on the use and applicability of blockchain technology in industry"[93].

This project was launched in 2018 and is about creating a platform for Industry 4.0 that would "allow its members to create prototypes in laboratories or controlled environments, as well as validation, experimentation and analysis of new products and services based on technology that can offer them differential value compared to competition"[94].

It is expected to have great impact upon the companies involved as it explores the applicability of blockchain technology in advanced manufacturing, automation of blockchain operations adapted to industry and pursues building a collaborative platform for experimenting, testing and disseminating Industry 4.0 results and impact.

Tecnalia, jointly with **the Italian Ministry of Economy and Finance (MEF), Accenture (CAN, Italy), PNO (Belgium), ELEX (Italy), Ayuntamiento de Santander, SOFTIM (France), Universidade de Coimbra (Portugal), JIBE (Netherlands) and Malta Information Technology AGENCY (MITA)** are participating in the project **POSEID-ON: Protection and control of Secured Information by means of a privacy enhanced Dashboard** that through the means of blockchain Aitortechnology, smart contracts and cutting-edge technologies, is developing a "scaleable platform" in order to "safeguard the rights of data subjects" and "support organisations in data management and processing while ensuring GDPR compliance"[95].

89 AMETIC. "AMETIC Comisión de Blockchain. Catálogo de empresas". https://ametic.es/sites/default/files//catalogo_blockchain_def_enero2020.pdf
90 Blockchain Economia (June 26, 2018). "Blockchain para certificar carne" Retrieved May 28th, 2020 from https://www.blockchaineconomia.es/blockchain-para-certificar-carne/
91 Blockchain Economia (June 26, 2018). "Blockchain para certificar carne" Retrieved May 28th, 2020 from https://www.blockchaineconomia.es/blockchain-para-certificar-carne/
92 EJIE. https://www.ejie.euskadi.eus/y79-contgen/en/contenidos/anuncio_contratacion/expx74j28258/es_doc/es_arch_expx74j28258.html
93 https://www.afm.es/es/noticias/afm-participa-en-el-proyecto-euskate
94 https://www.afm.es/es/noticias/afm-participa-en-el-proyecto-euskate
95 https://www.poseidon-h2020.eu/

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1	Natural Machines	43	Nordbo Robotics	80	Accexible
2	iCommunity Labs	44	Smart Robotics	81	Artificial Vision
3	Biodatup SL	45	Alerion	82	BitPhy
4	D&A Innovative	46	Ancora	83	Bleenco gmbh
5	Systems SL	47	AquaDAT	84	Conundrum
6	Data Value	48	Augmensys GmbH	85	Dynargy
7	Management	49	Barbara IoT SL	86	Enerbrain
8	Graphtext	50	Binary Soul	87	Enerlog Systems
9	IntegraPdM	51	Coologger	88	Kevo Technologies SL
10	LINQcase	52	Factory	89	Mosaic Software Patcha
11	Industrial Solutions	53	ELON	90	Relimetrics GmbH
12	Metis Labs	54	Integra Factory	91	Summarize GmbH
13	Mobile Lean SL	55	Is it Fresh	92	Xnext
14	Taniwa Soluciones	56	Sensing Tox	93	InoCure
15	ALIAS ROBOTICS	57	Myruns Technology	94	Nucaps Nanotechnology SL
16	BARBARA IOT	58	Nexmachina	95	Teknam (Nantek Hub SL)
17	COUNTERCRAFT	59	Solutions Blob	96	SATLANTIS
18	CRAS VIGILANS GROUP	60	Purple	97	Sayma
19	CYBERTIX	61	Spotlab	98	Infolagun
20	ENCRIPTIA	62	Tagenes	99	URBEGI Inserción
21	ENIGMEDIA	63	Tormesh	100	Lantik
22	ENSOTEST	64	AllRead Machine	101	Cymba
23	EUROCYBCAR	65	ASIMOB	102	Kalmia
24	GAPTAIN	66	DevisionX	103	Alquileres Chaco
25	GLOBE TESTING	67	Ikustek Vision Systems Lab	104	ebi talleres electrotecnicos S.A.
26	HDIV	68	INOVAKO	105	Intenance
27	IRONCHIP TELCO	69	Neurolabs	106	Versia
28	JAKIN CODE	70	Nuavis	107	Izar Cutting Tools
29	KEYNETIC TECHNOLOGIES	71	Pix Force	108	taladrados especiales sl
30	KIDYTECHY	72	Siali	109	Mecanizados Indarpak
31	OPENCLOUD FACTORY	73	SIGMARAIL	110	DOISTUA, S.A.
32	OSANE	74	3D Click		
33	PERSEUS	75	ARTHYLEN		
34	REDBORDER	76	Blinkin		
35	RELYUM	77	Gleechi		
36	RKL INTEGRAL	78	OROI		
37	SAINT INTELLIGENCE	79	Xoia Software Development		
38	SEALPATH				
39	SMOWLTECH				
40	TITANIUM INDUSTRIAL SECURITY				
41	WIMBITEK				
42	ZURA TECHNOLOGIES				

- Additive Manufacturing
- Blockchain
- Big Data/Advance Technology
- Cybersecurity

- Robotics
- Drones
- IoT
- Artificial Vision
- Augmented/Virtual Reality

- Artificial Intelligence
- Nanotechnology
- Space
- Services
- Leasing
- Engineering
- Machine Tools
- Components

Figura 4: List of Start ups and SME companies in The Basque Country that can take advantage of Blockchain.

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4.2.2 Developers, start-ups and beneficiaries of blockchain technologies in Aragon

The **Blockchain Ecosystem of Aragon**, formed when the Community joined the Alastria network, works to unite companies linked to Blockchain, disseminate the impact and encourage the development of blockchain technology among the rest.

There are several organisations with interesting projects in this technology working in Aragon, some of which were submitted to the Alastria open call, where annual awards are given to these initiatives:

Impact-Hub Zaragoza is an accelerator of Smart-ups that defines itself as a "business agitator" for the dissemination, promotion and fostering of the fastest growing technologies in Aragon, and consolidates itself as the regional Think Tank for blockchain; to publicise and understand how this technology can transform many of Aragon's economic sectors and companies. Among its numerous activities, it promotes workshops, events, networking and workshops, training, blockchain projects, and develops various use scenarios with this technology.

Inycom is a technology company that works on various use scenarios. One of them is the application of blockchain to the supply chain to have real-time information and thus plan the production chain more effectively. And another project is the certification of identity to guarantee the legitimacy, origin and authorship of documents. It also integrates blockchain into its Wallet ID (digital identity) technology, for the development and management of the self-sovereign identity of users with respect to information systems and entities.

Hiberus Technology is a Company specialised in ICT, business consulting, technological development, digital transformation and outsourcing work in the field of social cryptocurrencies, for their use as a means of payment in a private network of establishments. Another project in which it is immersed is the development of the possibility of using blockchain as a system for connecting databases between public administrations, to facilitate their interoperability.

Oesía and Open Canarias, as already mentioned, are two entities that develop the distributed register of offers for public tenders of the Government of Aragon: creating a hybrid network (combining Ethereum and Hyperledger Fabric).

Instituto Tecnológico de Aragon (ITAINNOVA), a leading technology centre in Aragon and partner of BLOCK4COOP, has carried out several proofs of concept, and develops three blockchains for commercial use.

- *Platform of the Spanish construction industry (PTEC)*, of the Ministry of Science, Innovation and Universities. It is made up of one hundred companies, from large construction companies to SMEs; and this project is carried out by ITAINNOVA together with BECSA, builder of the Valencian community. 30 companies are involved in the work chain; from design to purchase, transportation, automatic payment for materials, construction delivery, and the post-sale phase. Thanks to Smart Contracts money is released for the payment of the supply determined exactly in the project; thus giving greater confidence.

  The project integrates the BIM modelling software, to trace the changes in the design of the work; adding responsibility for changes, to maintain its neutrality; and deliver supplies on time.

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- Another project is for the supply chain of a food company, **ALDELIS**, an Aragonese processed poultry meat group. Its production chain begins in the chicken slaughterhouses, continues in the processing factories and is stored to be distributed in supermarkets and food stores. They have a chain from farms, slaughterhouses, semi-finished factories and storage warehouses.

- And *Fitotraza* is the project that works for the use of chemical products in agriculture. To trace phytosanitary products used in the field, chemical products against pests, which are dangerous due to misuse.

    This project is developed in some wineries of the Denomination of Origin of Cariñena (Zaragoza) and aims to control the use of phytosanitary products on farms thanks to this block technology, thanks to the combination of IoT and blockchain, it will be possible to spray with machines are automated to use just the right amount. In the chain will be the manufacturers of the products, the machinery and the farmers.

ITAINNOVA on the other hand is the ECO of Alastria in Aragon; the head of the region's blockchain ecosystem, and they've put an Alastria blockchain node in their lab, and tested various blockchain use cases and proofs of concept in the Alastria test network.

Aragon; another Spanish start-up will revolutionise the creation and management of companies; where two young Spanish developers have created this platform aimed at facilitating the decentralisation of companies and businesses around the world, providing them with the necessary tools to create their own decentralised autonomous organisations (DAO).

DAO: they are organisations or companies that far from being managed as usual by a CEO, legal representative or a board of directors; they are, as their name suggests, self-managed in a decentralised way through the use of smart contracts executed on a blockchain and where virtual voting takes place in which investors and owners participate remotely.

The objective of this start-up, Aragon, is to offer, thanks to an Ethereum-based platform, help and facilities so that anyone can easily create these DAO organisations; and thus be able to eliminate the need for intermediaries in the creation and maintenance of companies; giving agility to the process without the expense of professionals.

On this platform, which is still in the alpha phase, it will be possible to access the entire structure and requirements to create a company: articles of incorporation, accounting, payroll and social insurance, funds and payments, voting among its members for taking decisions and business strategy, all in the same single interface, where ease of use prevails.

 What does Aragon consist of?

The project has two fundamental elements:

a) **Aragon Core**: It is a decentralized app that runs on the Ethereum blockchain and that facilitates the creation and maintenance of decentralized companies without the intervention of intermediaries.

b) **Aragon Network:** it is a kind of digital jurisdictional framework designed to facilitate the operations of companies, entrepreneurs and investors.

Within this legal framework, these companies also have a decentralized court system in case there are discrepancies.

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The platform also has its own token, ANT, which will be used to make decisions about each aspect of its operation.

It is currently available for download and in web version, and the project community has more than 2,300 members with more than 2,000 companies testing it.

Source: Aragon website

Digitanimal, a satellite start-up that seeks to develop digital technologies for the livestock sector with the close collaboration of **ETSIAM** (University of Córdoba). Digitanimal will generate new innovative services in the agri-food chain through the use of IoT and blockchain thanks to support from the FTI Cattlechain Project (H2020) (www.cattlechain.eu).

The co-founder and director of Digitanimal is Carlos Callejero, co-founder of four technology-based startups: Digitanimal, Sensowave, Alfa Imaging, and Advanced Radar Technologies.

A local initiative in Zaragoza is called **Hurler and Vaulter,** and it is a start-up whose mission is to create identities for works of art using Blockchain technology, and that allows them to be sold worldwide. The technology allows the artwork to be sent along with other supporting documents to obtain a "digital security title" for property and to safeguard the property. Its agents sell the work among its clients.

It is based on Ethereum. The final objective of the 'start-up' accelerator is to offer a first business window that serves as a showcase to monetise creations.

There is an interesting initiative which is the Chairs that take advantage of their synergies to be able to spread the technology for everyone. In this case, the **Inycom and Unizar Chair**, which thanks to the "Blockchain within everyone's reach" cycle, present a series of activities commissioned by the association.

More information:

https://www.inycom.es/

News: https://www.inycom.es/actualidad-noticias/la-catedra-inycom-y-unizar-presentan-el-ciclo-blockchain-al-alcance-de-todos

http://www.unizar.es/actualidad/ficheros/20191008/50510/blockchain_mike_barrow.pdf

Tecnara, the Cluster of ICT, Electronics and Telecommunications Companies of Aragon. Tecnara is the perfect forum for knowledge among companies in the sector, where partners for collaboration in developments and projects can be located both regionally and nationally through their participation in national and international networks.

Tecnara and BlockchainAragon have signed an agreement for dissemination and training in blockchain technology. More information here:

More information: http://tecnara.es/

News: https://www.blockchainaragon.com/tecnara-y-blockchainaragon-firman-un-convenio-para-la-difusion-y-formacion-en-la-tecnologia-blockchain/

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4.2.3 Developers, start-ups and beneficiaries of blockchain technologies in Aveiro

The emergence of start-ups is essentially the result of challenges launched or programmes funded mainly by recent graduates who are committed to innovation. In Portugal, a number of companies have been formed, mainly by young graduates. Examples of these are companies such as:

- **Public Mint Inc.** presented as: "the first fiat-native blockchain settlement layer for programmable money".

- **Genesis studio,** created for the full adoption of Blockchain and modern distributed accounting technology (DLT).

- **Intellect** is a technology-driven and customer-focused consulting firm which was established in 2019. Our diverse range of solutions are a unique combination of data science, amazing design philosophy, software engineering and architecture. We get to the root of the clients' problems to offer them effective solutions.

- **Taikai**, a start-up that creates challenges between large companies and blockchain start-ups. Taikai is a challenge platform that uses Blockchain. It has raised 350,000 euros and is headed by Mário Alves, who left banking to lead the project.

- **WalliD**, Portuguese blockchain start-up that received an investment of 600,000 euros. Among the investors is the National Mint - Casa da Moeda. WalliD developed an identity registration and management tool in the Ethereum blockchain platform. Through the WalliD tool, a user can store his/ her identification documents in a blockchain-based digital wallet. This information can then be used to validate the person's identity in the services of companies and organisations that adopt the WalliD system.

- **Bitcliq**, this Portuguese start-up is the first worldwide blockchain market for the fish trade, connecting fishing fleets with buyers and allowing the purchase of fish when they are caught at sea by retailers and restaurant owners. In addition to connecting fishers to buyers, the platform also allows full traceability from the catch location to the table, which is becoming essential for an ecosystem with ever lower prospects due to illegal fishing practices and ocean pollution.

- **Zenithwings** is developing a blockchain solution to help protect wine producers and consumers by allowing digital certification and product traceability.

- The Portugal Tech Programme also has 40 million available to invest in new Portuguese teams.

- **BlockStart,** the European consortium led by the Portuguese Bright Pixel that aims to boost the adoption of Blockchain in SMEs, has opened applications for developers and start-ups to develop solutions based on this technology applied to retail, fintech and information and communication technologies. The objective of the initiative is to support 60 entrepreneurs and 60 SMEs with financial help from the European Commission.

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4.2.4 Developers, start-ups and beneficiaries of blockchain technologies in Auvergne

Regional companies:

- **4D-Virtualiz :** the company provides its expertise to support the implementation of innovative projects in mobile robotics, instrumented and autonomous vehicles and offers a 3D simulator of environments, systems and sensors/actuators for the development of real-time applications for advanced robotics and autonomous vehicles.

- **AddUp :** supplier of industrial metallic 3D printing solutions (powder bed fusion, directed energy deposition, electron beam fusion), designer and manufacturer of printing machines, addressing a wide variety of application markets: automotive, health, aerospace…

- **Almerys:** the health insurance company offers solutions and services for data processing, compliance management, product distribution, management delegation and the implementation of differentiating services. It is involved in three European projects on the subject of blockchain technology applied to different sectors: MyHealthMyData[96] (health), PTwist[97] (plastics value chain) and CUREX[98] (health).

- **Braincube:** supplier and designer of solutions for collecting and analysing personalised data to digitise and make industrial production systems and processes more autonomous and agile (IoT platform, Edge, Cloud, etc.).

- **CIPAM:** expert integrator in the fields of identification and traceability working for a wide variety of sectors and markets, CIPAM uses identification techniques (barcode, Datamatrix, RFID, RTLS, Industrial vision, Laser marking) to follow goods, equipment or people and the interface with the environment (PLC or information system) by adding software functions (middleware, database, user interface, web portal, etc.).

- **Di-Analyse Signal:** Di-Analyse Signal, an engineering and technical study company, is an expert in signal processing applied to the monitoring of rotating machines. The proposed innovation is a global solution for managing predictive maintenance, the nerve centre of which is called "Lesly". The latter has the particularity of exploiting the data available in an existing automaton or numerical control to anticipate mechanical breakdowns without adding sensors or stopping production.

- **DomRaider:** first company to carry out a 100% French Initial Coin Offering, DomRaider is turning to blockchain technology by focusing on two main subjects: real-time auctions and dropcatching. The company developed Auctionity, a decentralised real-time auction solution for digital assets. The objective of Auctionity is to make auctions more secure, faster and more reliable thanks to blockchain technology[99].

- **Effidence:** the company designs, develops and markets innovative navigation solutions. EffiBOT, a robotic trolley, a real logistics assistant with multiple uses for many sectors of activity: logistics, industry, construction, last-mile delivery. EffiNAV, an autonomous navigation system that can be carried on any type of mobile platform or vehicle. All the solutions developed by EFFIDENCE are created using very innovative cutting-edge technologies: signal processing and multi-sensor data fusion.

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96 http://www.myhealthmydata.eu/
97 https://ptwist.eu/
98 https://curex-project.eu/
99 https://www.domraider.com/auctionity/

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- **Exotic Systems:** expert in connected objects and intelligent systems, Exotic Systems supports industries (all sectors) in their digital transformation and develops solutions to address the issues of cost reduction and optimisation of turnover thanks, among other things, to equipment traceability and securing, optimising flows and resources, predictive maintenance or developing new business models.

- **I3D Concept:** expert in the field of metal additive manufacturing, the company's desire is to support laser sintering in the stages of maturity up to mass industrialisation and to offer a complete production centre in the near future.

- **INETYX:** the company develops, designs and markets innovative technologies, mono and multi-material metal 3D printers by laser micro-welding. This innovative technology, protected by patents, breaks with current 3D printing technologies such as laser or electron beam fusion of metal powders.

- **INOPROD:** engineering and design office serving companies wishing to identify and measure the risks and benefits upstream and during industrial projects to improve overall performance in relation to the following topics: System design, Risk management, Simulation of flow, Process simulation and Ergonomic simulation.

- **META 2i:** the company has strong know-how in study, creation of systems and applications for supervision. Above all dedicated to the optimisation of industry production workshops, expertise continues in the consulting and publishing of production monitoring and MES software. These systems' founding tools, integrating the development of specialised "business" modules, are optimised and communicate from the operator to the decision maker in order to create and complete the industrial information system of the factory and the workshop.

- **M-Tecks:** mechanical engineering company involved in various activity sectors such as energy, rail, aeronautics or even automotive, M-TECKS supports industrial companies in their research, product and process development approach, numerical simulation, engineering of machining and industrialisation processes.

- **PHIMECA Engineering:** engineering company specialising in the evaluation and optimisation of product and system performance. PHIMECA Engineering conducts design, dimensioning and optimisation studies of critical components and mechanical or physical system.

- **Sciences Computers Consultants:** support company in the optimisation of industrial processes and publisher of digital simulation software. Initially involved in the steel materials processing industry, the company has chosen to diversify its approach to various sectors (plastics, chemicals, food, etc.).

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Regional structures supporting companies in innovation:

- **Digital League:** digital cluster for industry in Auvergne-Rhône-Alpes. The purpose of the association is to federate, inform, animate, promote and represent the actors of the regional digital sector. With more than 500 members, the objective is to promote economic growth and employment in the region.

- **Hall 32:** private-public partnership (big companies, SMEs, rectorate, "pôle de compétitivité", policy makers), Hall 32 wants to offer a new approach of the vocational trainings aiming at creating a programme of excellence to train people for the industrial jobs which require high-qualified experts. One of the main goals is to break the negative popular vision of industry and give young people the possibility to access empowering jobs. It stands for a competence centre as well as a pilot plant, a vocational training place, a process lab when people can learn by doing.

- **Le Bivouac:** private-public initiative born of the will of Clermont Auvergne Métropole and the Auvergne region alongside 9 partners: large private groups (Caisse d'Epargne, Crédit Agricole, EDF, Engie, Groupe Centre France, Limagrain, Michelin and Orange) and teaching and research clusters (Auvergne TIC cluster). This varied ecosystem brings together major public and private players to host start-ups, support them in their growth, and thus develop digital technology in the regional territory.

- **ENE (Entreprises et Numérique) :** its mission is to improve competitiveness and promote innovation of Auvergne-Rhône-Alpes' SMEs by developing the use of digital technology, disseminating Information and Communication Technologies (ICT) within SMEs and to concretely support the digital projects of companies.

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4.3 Barriers and difficulties of implementation at the regional level: case of the Basque Country, Aragon, Aveiro and Auvergne

After everything described about Blockchain technology, it can be seen that its establishment in traditional networks (IT) is quite grounded. In the case of IoT, on the other hand, it is a technology that is being used in a more experimental way and that in the future could represent a turning point in the networks of industrial devices.Despite this, certain limitations or challenges that currently limit the integration of Blockchain technology in IoT devices can be detected.

- Storage capacity and scaleability: in Blockchain the chain size grows linearly, in this way the need for resources increases as transactions are completed. In devices limited to performing specific functions, such as those of the IoT, the capacities may be insufficient and not reach the minimum established for the proper functioning of blockchain.

- Regarding scaleability, in public blockchain networks the processing time increases with the size of the network, which may affect the needs of industrial networks that can demand speeds close to real time.

- Security: although there is a growing community of experts in favour of the implementation of Blockchain as a method of securing IoT networks, there are still problems that affect its implementation. One of the most relevant is the introduction of corrupt, not always malicious, data in the chain. If incorrect data is entered into the string, it will always remain there. That is why it is advisable to carry out exhaustive and periodic tests on IoT devices before introducing blockchain technologies in them.

- Anonymity and data privacy: to protect sensitive information on IoT networks, public/private key encryption mechanisms are commonly used. These mechanisms can be implemented in the devices themselves or in the network in which they are located. In the second case, latency can affect communication performance, while the first is limited by the device's own capabilities. A possible solution is the inclusion of cryptographic hardware in these devices to lower the computational cost and not depend on network latency.

- Smart contracts: in this aspect, one of the limitations is the fact that the code is distributed only to be verified, not to share the computational load. This problem has led to implementing communications that optimise computational load to suit the needs of these networks.

The Legal Barriers are:

- Smart contracts need a reliable source for the validation and verification of the reliability of the data sent. In the IoT this is challenging, as highly reliable and continuously maintained sensors are required to act as validators to detect possible incorrect readings or data corruption.

- Legal problems: according to Spanish law, a contract must be able to end in some way in all cases. In the case of Smart contracts this is not possible per se, but as an alternative a new modified Smart contract can be issued. This would cause the old contract to redirect requests to the new one, thereby complying with current legislation.

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- Another relevant aspect is the protection of the rights of investors in cryptocurrencies. In some countries, such as Malta, investment regulatory measures are already being established to offer protection and guarantees to users of these technologies.

- The introduction of Smart Contracts and artificial intelligence, incidentally, will pose enormous challenges for financial, accounting and legal professionals in general (including, of course, the areas of dispute resolution). It is essential that professionals in these areas develop the capacity to understand these advances, as well as the technical skills in the area of programming and information technology to respond effectively to these new challenges. In this sense, it will not be insignificant to consider the need for the introduction of computer programming disciplines in degrees such as law.

- Other challenges will be posed to Smart Contracts, such as questions related to the confidentiality of the contents of the contracts since they will be distributed in a decentralised way in Blockchain. Programming errors that are difficult to detect and that may produce unjust or undesirable results, the way transactions carried out through this type of contracts will be taxed, and the difficulties of regulation and supervision.

Another barrier is related to the human resources point of view. The profiles of technicians necessary for this evolution will in many cases be IT digitisation experts. They will need to be trained in regulations, protocols, security updates, obsolescence and above of all, blockchain frameworks such as Hyperledger Fabric, concepts that are totally out of the orbit of Goods tool manufacturers.

Last but not least, Blockchain technology is seen as a paradigm that will alter and replace the platforms on which we articulate existing digital businesses. This is seen as a barrier by integrators and companies since it looks like blockchain will need to replace previous digitisation achievements. However, blockchain and related technologies are built on top of existing digital protocols, they do not require starting from a blank slate. In fact, Blockchain is one more layer that that sits on top of previous digital platforms. It is important to explain that Blockchain is based on procedures that can be added on top of existing developments.

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4.4 Intersectoral collaboration opportunities

As can be seen, Blockchain has the potential to become a significant source of disruptive business innovations[100]. The application of Blockchain seems to offer considerable performance improvements and marketing opportunities. This technology also enables the successful creation of decentralised digital monetary networks. This success has led to further research into the usefulness of blockchains in other types of business and cooperation between sectors[101].

Several initiatives are available to create challenges or projects for collaboration in various sectors, essentially allowing start-ups to present technological solutions in various fields/areas.

For students, start-ups and companies to test and develop new solutions and business models based on this technology, Aliança has launched a portal that provides safe environments for the development of applications (sandboxes), in which it will be possible to experiment and develop these solutions.

They were then launched in the Blockchain Challenges portal, which are business challenges oriented to specific sectors and which use distributed technologies such as Blockchain to help solve specific needs in these sectors.

Three Blockchain Challenges launched by REN, Fidelidade and Abreu Advogados are currently available on the website. REN wants to put this technology at the service of the energy network. Fidelidade seeks to understand how this can help detect insurance fraud or change the experience of hiring, underwriting and claim management. Abreu wants to understand how Blockchain and smart contracts (computer protocols that facilitate, verify and guarantee negotiation or compliance with contracts, automatically and without recourse to intermediaries) can be used to make contracts and legal processes more efficient.

Technologically, it is developing with some speed thanks to the development and start-up of associations, intersectoral collaborations and platforms, both oriented to public networks and private business networks.

The firm commitment of the public and private sectors, together with the rest of the technology centres, universities, sector clusters and associations, make collaboration opportunities to promote and foster this technology.

In Aragon, as we have already mentioned, it is the public administration sector that is at the forefront of collaboration for the management of participatory processes, offering various values, such as trust, transparency and immutability, which fully fit the needs of this type of process. A blockchain platform could be defined in which trust was distributed among different entities and the system offers transparency and guarantees that the results are unchangeable.

There are sectors that have committed more firmly to it, such as the international trade sector that hybridises **financial services, industry, logistics, and transport, along with public administrations.**

100 White, G. R. T. (2017). Future applications of blockchain in business and management: A Delphi study. Strategic Change-Briefings in Entrepreneurial Finance, 26(5), 439-451.
101 Coyne, J. G., & McMickle, P. L. (2017). Can Blockchains Serve an Accounting Purpose? Journal of Emerging Technologies in Accounting, 14(2), 101-111

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This study estimates the following commercial exploitation models of the digital assets developed in this action (traditional disruptive models) in the Basque Country:

- Servitisation of Success: applicable to certain functionalities and services offered by the ecosystem. This type of monetisation is based on medium to long-term agreements that determine indicators of success. The user pays based on the degree of completion of said indicators through the services/products offered. It opens up a wide range of possibilities by being able to be applied to all services and functionalities offering great flexibility to adapt to extremely different use scenarios.

- Pay per use: monetisation through a basic Fee to access the application and additional payment for individualised use of each of the services/product.

- Payment for consumption/service: this type of exploitation, more traditional and modular, refers to the exclusive payment for provided functionality. It will involve an annual fee for management and creation of enablers. In this case the client will be able to access a limited range of functionalities and services. This covers the entire value chain (Technical Maintenance, data network management, Technical Assistance and Support, Features, updates and technical improvements ...)

- Unlimited use of the platform: in this model, the client will pay an annual fee to be able to access all the modules and services of the digital platform according to their needs. This option specifically includes the maintenance and periodic dynamisation of the different types of middleware, as well as the integration with all the IT processes of the industrial client, validation and optimisation of resources, detection of functionalities, updating of the platform and continuous development of the tool in terms of content and data processes.

- Blockchain technology has all the assets (security, traceability, forgery-proof) to be a relevant and interesting digital development opportunity for economic players.

- Still little mastered on a large scale and a source of misunderstanding for many companies, it is now necessary to continue raising awareness of this technology among all economic sectors in Auvergne- Rhône-Alpes. The use of Blockchain will be justified only by its operational applications. Indeed, the mobilisation of industrial manufacturing companies for this technology will only be possible through specific application cases demonstrating the usefulness of Blockchain to effectively meet their needs. As a reminder, the region has many players in the agrifood sector and the energy sector, which are two of the three priority targets determined by the national Blockchain strategy. For example, inAuvergne-Rhône-Alpes there are many works of art related to energy production for which Blockchain technology could prove useful for remote maintenance. Other sectors, such as mobility, are of definite interest for Blockchain applications, which can simplify the car rental offer by establishing "smart contracts" or traceability of customer data.

- The relationship of trust established by technology can promote the emergence of collaborative projects. Thus, certain opportunities have already been seized upon by regional companies which have been able to propose cross-sectoral projects allowing sectors and actors of diverse natures to collaborate: Auctionity (https://www.domraider.com/ auctionity /), PlasticTwist (https://ptwist.eu/), My Health My Data (http://www.myhealthmydata.eu/), CUREX (https://curex-project.eu/)...

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4.5 Interregional collaboration opportunities

Blockchain will help to solve the problem of trust more efficiently. The widespread adoption of Blockchain will lead to many business innovations as well as cooperation between regions.

As far as Portugal is concerned, in terms of interregional and countrywide collaboration, a Portuguese company, Bright Pixel, has taken the lead in a European project to drive the adoption of Blockchain and cooperation between regions and countries. The objective is to initiate small and medium enterprises to use the potential of blockchain technology and implement innovative solutions developed by programmers. This consortium also aims to support entrepreneurs in this area to validate their ideas in the market, and also to leverage good practices in the use and implementation of this technology.

The Portuguese Blockchain Alliance has also launched creative challenges oriented to collaboration between sectors and regions for the implementation of Blockchain solutions-oriented to market needs. These challenges of Blockchain are destined to all those who have an interest in the technology: 1) Students who seek to specialize in Blockchain and want to test new applications; 2) Startups who seek to develop their business through the technology; or even 3) companies that want to adopt Blockchain in their way of working, facilitating or improving their processes, having this way the ideal opportunity to experiment their new ideas and test their own applications with the market.

Applications are also available for collaborative projects such as Portugal2020[102], Interreg PT-ES[103], Interreg sudoe[104], Interreg MED[105], Interreg Europa[106] and European[107] where Portuguese companies and organisations participated.

Examples are BlockStart: whose goal is to support start-ups connected to Blockchain. Three phases of the programme are scheduled and in each one of them 20 programmers and start-ups will be selected that will receive up to €20,000 in financing.

The creation of several national and international consortiums, as well as the increasing impact and implementation of pilot projects and proofs of concept and other services in a practical way in almost all markets and sectors, not only in the financial sector, show the transformative capacity of Blockchain that is impacting the entire business fabric and market thanks to interregional collaboration, with a clear focus on how to materialise its benefits.

With regard to Alastria and the active participation of the Government of Aragon, it can be established that this is a great interregional collaboration in Spain, formally constituted on 17 October 2017.

It is the first national and multi-sector Blockchain consortium in Spain, where more than 70 Spanish companies are represented, and whose objective as a multi-sector association, promoted by companies and institutions, is the establishment of a permitted semi-public blockchain infrastructure that supports services with legal efficacy in the Spanish sphere and in accordance with European regulation.

The mission of this consortium is neutral, with the aim of building a structure or platform without a specific use scenario or business model.

The sectors of the companies of this consortium are mainly banking, energy and telecommunications, but it is open to all sectors, companies and public sectors.

102 https://www.portugal2020.pt/
103 https://www.poctep.eu/pt-pt
104 https://interreg-sudoe.eu/prt/homepage
105 https://interreg-med.eu/
106 https://www.interregeurope.eu/
107 https://ec.europa.eu/programmes/horizon2020/en

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The platform will be based on Ethereum, as it is the most widespread blockchain technology, oriented to smart contracts and has a wide community of developers. Given that it will be a permissible network and that the performance requirements will be high, **Alastria** will be built with Quorum, which makes it possible to take advantage of developments for Ethereum and use technology designed for corporate services.

The interregional collaboration can be established if there is not any overlap between the stakeholders. An option to ensure a common interest is to map each actor within the added value chain of a Digital Business.
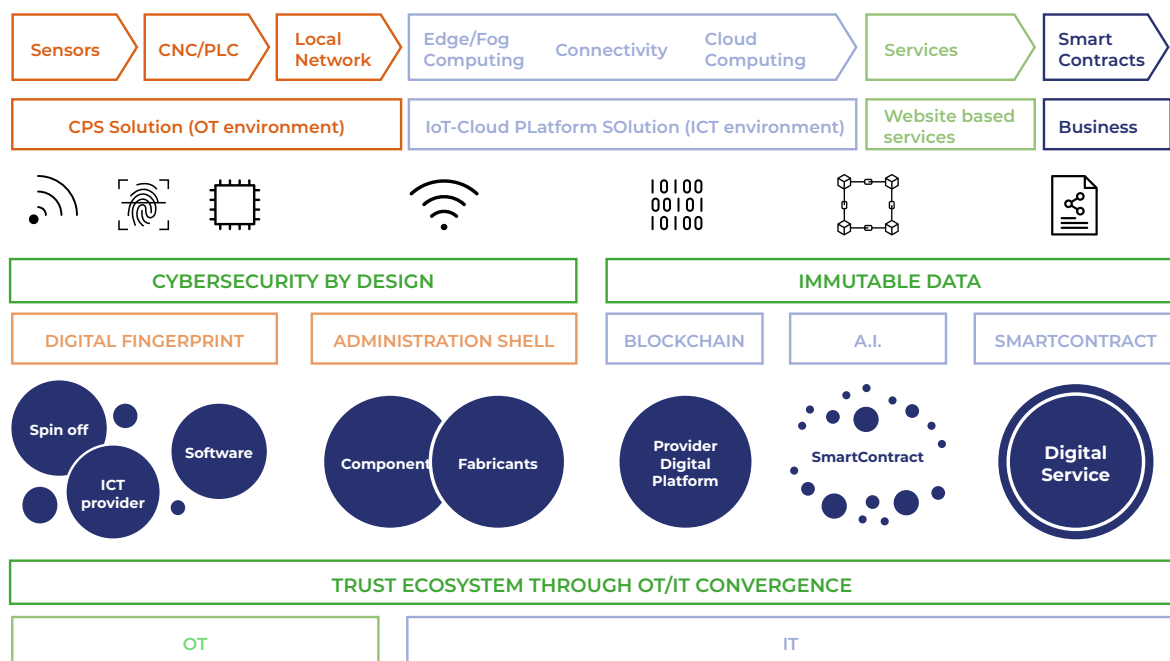

Figure 4: Schematic representation of the added value chain and the Basque companies' place in the chain (logo placement under review)

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In the same way as what was mentioned for the cross-sectoral nature of collaborative projects, Blockchain technology strengthens trust between economic players contributing to improve cooperation between companies and the development of interregional projects.

It turns out that Be-Ys Group, whose be-almerys brand, expert in high technologies applied to insurance and health, is located in Clermont-Ferrand, participates in several European projects (H2020 programme) concerning the application of Blockchain technology to different sectors with many European partners. These collaborative projects promote exchange between companies, universities and public actors, in particular My Health My Data and CUREX projects. These two projects concern the development of a system and a platform for exchanging health data in order to secure its sharing and guarantee reliability and real possession for each patient. Blockchain technology will allow, among other things, the development of a "citizen-driven" interface where patients will have full management of their own data and will encourage the use of "smart contracts". The company is also a partner in a third European project, PlasticTwist, the main objective of which is to promote recycled plastic by raising awareness of all players in the plastic value chain about new forms of plastic practices as an asset. This mobilisation of actors is done via an open platform based on Blockchain technology.

Blockchain technology, through trust created among players, is a relevant tool for setting up interregional projects where the disparity and diversity of the players involved can sometimes be a barrier to collaboration.However, it should be noted that many industrial companies have taken the plunge and gained experience in collecting and managing data. This dynamic is conducive to the future adoption of technologies such as Blockchain allowing reliable and secure management and sharing of data to serve needs and uses.

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CONCLUSIONS AND RECOMMENDATIONS

5.

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5. CONCLUSIONS AND RECOMMENDATIONS

Since this study is among first attempts at exploring blockchain implementation in SUDOE regions, some conclusions and recommendations are appropriate. It is worth noting that these conclusions are, at this stage, a more technical in nature rather than practical.

In any case, there is concrete evidence that blockchain technology is developing in the SUDOE space. A support policy framework (through RIS 3 or regional Industry 4.0 Strategy for example), initiatives with results and vivid interest demonstrated by policy makers, developers and users in the Basque, Spanish, Portuguese and French regions prove all of this.

There are also relevant sectors and areas detected in the above-mentioned SUDOE regions where blockchain technology through several pilot projects and initiatives is already developing: in the agricultural sector, industrial sector (aerospace, automotive, construction, etc.) and public sectors.

On the other hand, some barriers and difficulties in blockchain implementation were also detected. These are more linked to security issues, scaleability, anonymity and data privacy and not ultimately legal barriers.

In technical terms, regarding the data that supplies digital contracts or Smart Contracts, there are systems that allow the immutability of the data to be maintained once it is within the system, but the real problem in terms of trust is found in the source of the data. Being able to track the data from the source itself, considering that the source itself is reliable, is a plus in the confidence of external components for conducting digital business.

This is why the INDUSTRY 4.0 strategy combined with Blockchain Technologies want to promote improvement of the business and industrial fabric, we want to propose this paradigm shift or adapting to new digital business models through Smart Contracts to conventional industries, such as manufacturers of equipment and machine tools, highlighting trust between companies and between data sources.
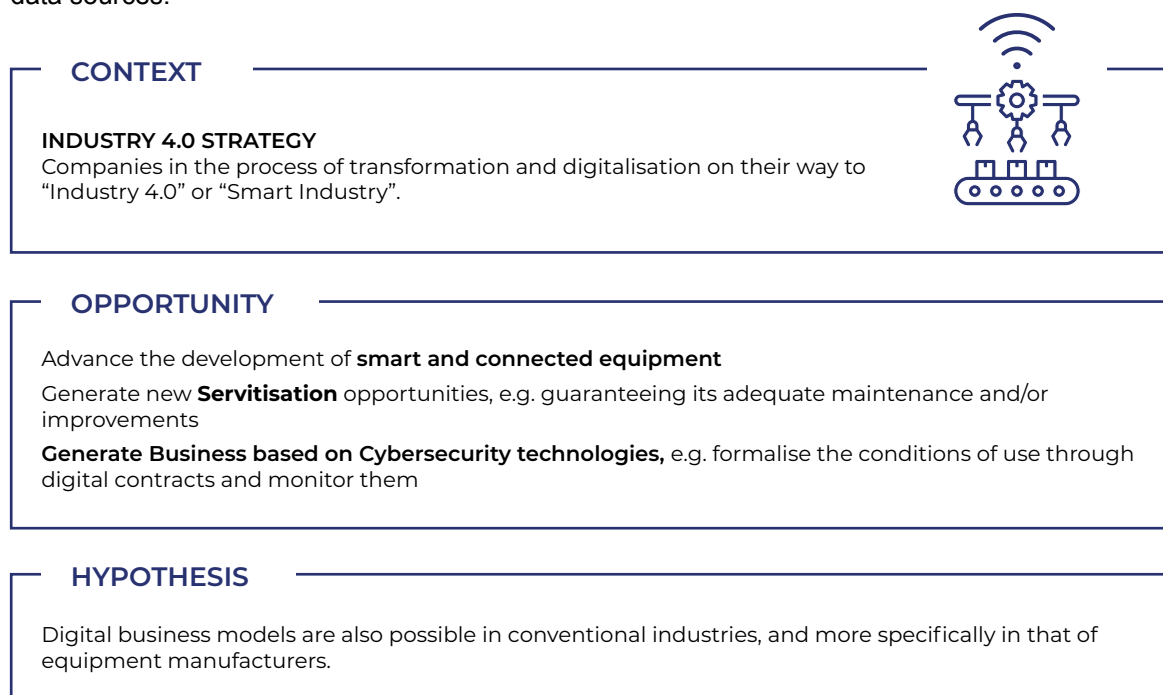
CONTEXT

INDUSTRY 4.0 STRATEGY
Companies in the process of transformation and digitalisation on their way to "Industry 4.0" or "Smart Industry".

OPPORTUNITY

Advance the development of **smart and connected equipment**

Generate new **Servitisation** opportunities, e.g. guaranteeing its adequate maintenance and/or improvements

Generate Business based on Cybersecurity technologies, e.g. formalise the conditions of use through digital contracts and monitor them

HYPOTHESIS

Digital business models are also possible in conventional industries, and more specifically in that of equipment manufacturers.

Figure 5: Schematic representation of the evolution of Industry 4.0 and the documentary hypothesis

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Thus, the greatest added value of this technology will be the creation of something as immaterial but as important as trust. This trust should be achieved based on these roadmap steps:

- Technologies and algorithms that guarantee the integrity, identity and immutability of the data from the sensor to the client user. Giving the certainty that the data has not been modified in the process.

- Through real use scenarios in industry that implement the different business logics adapted to the digital world with digital contracts or Smart Contracts. These SmartContracts will also be auditable.

- Demonstrating different business models of the platform developed and adapted to the specific needs of each industry. In principle it will be as an external service or as its own service within the network of trust that the different industries will share within their own infrastructure.

- In the sharing of business data between different industrial companies. All companies will have access to the data that affects the Smart Contracts in which they participate.

This model should consolidate pay-per-use schemes that are supported by machine monitoring data that unequivocally demonstrate the time of use of the machine or goods in production/use. Putting this data into a contract and having the appropriate technology for continuous verification of compliance is an important advance in the management of these new models.

The following diagram summarises the technical conclusion of the study in a form of a chain of links.
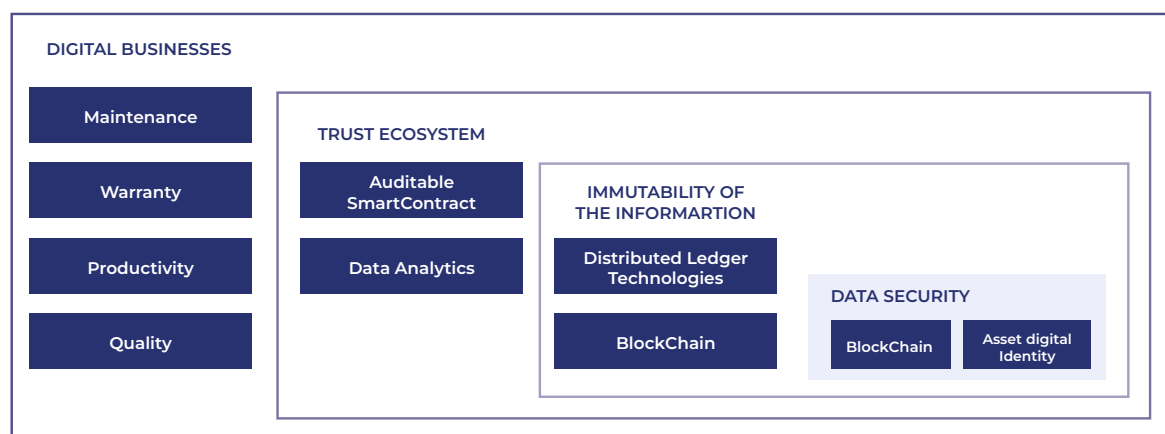

Figure 6: Schematic representation of key chain of links leading to Digital Businesses

Digital businesses are on the way, and they will be here to stay. To do this, an Industrial Trustworthy Ecosystem must be created where Smart contracts and data analytics play the main role. To do so, it is a must to create immutable information and this is where Blockchain and similar technologies (Distributed Ledger Technologies) play a crucial role to make this reality come true. Nevertheless, this immutability needs to be complemented with further Data self-sovereignty and Digital Identity to make sure that the data belongs to the right asset.

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