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Blockchain: a brief review of Agri-Food Supply Chain Solutions and Opportunities

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ABSTRACT

This article aims at presenting Blockchain and Distributed Ledger Technologies from business perspective (although providing adequate technology context) and, especially, highlighting concrete implementations in Agri-Food Supply Chain, bringing security, transparency and robustness to solutions, and enabling the creation of added value through the provisioning of information to consumers which allow them to understand the origin, the transformation and the transportation of agri-food goods. It also brings some examples of European Programmes and Projects that are supporting innovative solutions to reach the market.

1. Introduction

While the best-known application of Blockchain is Bitcoin, Blockchain and distributed ledger technology are not limited to this important use case or even to the fintech domain (Crosby et al, 2016). In fact, Blockchain is still and emergent technology but there are already relevant use cases in sectors like agri-food and logistics, especially combining a secure, fully transparent and trustworthy storage with Internet of Things, allowing end-users to trace goods from their origin till consumption and ensure transportation conditions were followed (Fernández-Caramés et al, 2018). Other usage scenarios with immense potential are also being explored in areas like pharmaceutical, where drugs and other goods need to be stored and transported in stable conditions but also where tampering is quite frequent in high value products (namely when drugs can be used for recreation purposes).

The present article will not discuss and present the technology underneath Blockchain and its applications and will focus on how a technology most known in financial markets can be used in distinct and important activities to bring trust across various value chains. Part of this article will be devoted to present some European Union funded projects that are contributing to accelerate innovation around Blockchain and Distributed Ledger Technologies and supporting initial steps of product development and market entry and, also, fostering cooperation between Academia and Small and Medium Enterprise to develop jointly solutions to solve real problems in real economy.

During the next section, we will briefly introduce concepts related with the technology itself, providing context to the following sections. On Section 3, some applications of Blockchain in Agri-food and Food Supply Chain will be presented. Section 4 is dedicated to highlight some existing Acceleration Programmes dedicated to Blockchain as well as showcasing some of the most important prototypes selected and supported technically, financially and in go-to-market strategies.

Section 5 will be dedicated to identifying some opportunities, trends, and challenges.

Finally, conclusions will wrap the context and next steps.

2. Distributed Ledger Technology and Blockchain: Concepts and Characteristics

Distributed Ledger Technology (DLT), according to (Rauchs, et al., 2018), is defined by several authors differently, incompletely, and sometimes, inconsistently. The concept emerged, according to the authors, around 1982 in (Lamport, et al., 1982) "The Byzantine Generals Problem" as "computer systems must handle [...] conflicting information in an adversarial environment".

(Rauchs, et al., 2018) proposes a formal definition of a DLT as a "system of electronic records that enables a network of independent participants to establish a consensus around the authoritative ordering of cryptographically validated ('signed') transactions. These records are made persistent by replicating the data across multiple nodes, tamper-evident by linking them by cryptographic hashes. The shared result of the reconciliation/consensus process – the 'ledger' – serves as the authoritative version of these records".

Therefore, a DLT system produces and stores a set of authoritative records validated and executed through a consensus process which involves multiple distinct parties, in the absence of any central authority. New proposed entries to the ledger are disseminated to the network and added as records by record producers. All instructions that are part of a now-confirmed record transaction are executed automatically by all the auditors. Yet, records include only transaction data that has previously subjected to network consensus rules.

Blockchain concept has also various definitions as, for example, in:

- (Haber, et al., 1991) as a "distributed database that autonomously maintains a continuously growing list of public records in units of 'blocks' secured from tampering and revision";
- (Bayer, et al., 1993) as "a chain of cryptographically-linked data blocks to efficiently and securely timestamp digital data in distributed systems using crypto-graphic hashing functions and Merkle trees";
- (Atzori, 2015) as an "irreversible and tamper-proof public records repository for documents, contracts, properties, and assets [that] can be used to embed information and instructions, with a wide range of applications".

Although initial works are from early 1990s, this concept only emerged in 2008 after the publication of a White Paper from Satoshi Nakamoto (a pseudonym) defining the first relevant use case of Blockchain, Bitcoin (Nakamoto, 2008).

Blockchain is, therefore, an implementation of Distributed Ledger Technology and, despite its natural association with Bitcoin, is now being used in various other domains like Agri-food, Logistics, Retail, Shared Economy, Real Estate or Legal matters.

Briefly, Blockchain has 4 main characteristics:

- Decentralization, probably it most distinctive feature, opposes to traditional transactions systems, by allowing two peers to perform transactions between themselves without any central authority authentication and validation.
- Persistency relates to the distributed and redundant storage across the network (which brings resiliency and improves scalability). Each transaction is spread across the network to be confirmed and recorded in blocks. Each block is verified by nodes within the whole network (in the most common scenario) before being saved. This is the feature that prevents tampering (of course, cryptography is in place implementing Merkle trees and hashes). Any attempt to forge a record after being confirmed by several nodes is easily detected.
- Anonymity is linked with the fact that, in many cases, users can only interact with the network using a token that was previously generated. This feature is not always present (or in its full extension) due to some differences related with implementation requirements or characteristics.
- Auditability is another key characteristic of Blockchain. Every transaction is validated and recorded using a timestamp, its "chain" nature allows to access, verify and trace linked previous blocks iteratively and securely since all data is ciphered.

There are three distinct types of blockchains: public, private, or hybrid block-chains. Public blockchains (like Bitcoin and Ethereum) are open to public and everyone can join and participate. This provides full transparency of recorded data and transactions as well as is a completely decentralized approach. Selected participants (like those that are miners in Bitcoin) collected rewards when assessing transactions. Private Blockchain (like Hyperledger Fabric or Corda) are managed by one entity or consortium and use access controls, restricting the participation to those within the network. The third type of Blockchain is the Hybrid Blockchain (like XinFin, Ripple and Dragonchain) which was created aiming to use the best of both Public and Private Blockchain. It provides transparency but also defines permissions for users. One of the most relevant hybrid implementation scenarios is Hybrid IoT which allows full transparency for external users (e.g. the consumer) while restricting access to the network to trusted parties. Sensors have access to the public network, for example, and public in general would only access the public part of the Blockchain.

Relevant in these ecosystems is also the concept of a Smart Contract, defined in ISO/TR23455:2019 as a "computer program stored in a distributed ledger system wherein the outcome of any execution of the program is recorded on the distributed ledger". (Tapscott, et al., 2019) provides a definition that is related with functionality: "smart contracts are computer programs that secure, enforce, and execute settlement of agreements between people and organizations". This practical approach of a contract leads to many implementations of business and financial transactions, namely by enforcing agreements and automatically (in an unmanned process) processing payments or compensations previously arranged between parts. Aside financial transactions, smart contracts may relate use data collected by IoT devices – for example, by using sensors to measure soil conditions, a retailer can decline accepting vegetables that are not organically farmed or meat from cattle which was not breed in a certain location (using GPS or RTLS).

3. Blockchain in Agri-food and Food Supply Chain

As stated initially, Blockchain Technology is overcoming the umbilical relationship with Bitcoin, proposed in (Nakamoto, 2008), as the support layer for a completely decentralized approach to issue and transact money without relying in any centralised regulation entity like Central Banks. This implementation has generated a lot of concerns both in Central Banks and in Government Officers because it could become an umbrella to frauds, money laundering or other illegal activities, protecting these actors from being known (it is fully anonym).

Recognizing the potential virtues of Blockchain, several Central Banks are now considering the usage of what is called "Central Bank Digital Currency" (CBDC), including the European Central Bank, due to its efficiency, financial inclusion, ability to prevent illegal activity, be a real alternative to cash, capacity of protecting money as a public utility, safety in payments, increase competition among banks and financial safety. Other Financial applications are being developed, based on asset tokenization to guarantee loans and factoring operations, engaging individual investors in lending, implementing complex financial instruments (like Credit Default Swaps), for example. Other FinTech applications are related with insurances and dynamic risk analysis, like for instance new pricing models for car insurance based on IoT Data, Weather Insurances (based on weather stations data) and Earth Observation Data.

Yet, this article focuses applications related to Agri-Food and to the Food Supply Chain.

Blockchain technology provides a trusted environment for many parties as the ones across the agriculture and food processing sectors until the consumer. In fact, nowadays customers are demanding products produced sustainably, organically and origin certified (or even locally produced). These trends are present in many countries and are related with consumers' income and environmental awareness. Aligned with these new requirements is the ability to collect data along the full value chain using IoT devices, measuring soil characteristics, weather conditions, watering, sugar levels but also during the logistics and transformation to ensure proper transportation and processing conditions like temperature and humidity. Data-driven applications during the agriculture production are generally named as "Smart Agriculture" (Xiong, et al., 2020) or "Smart Farming".

Smarter farming is highly dependent on quality data that may be gathered from Earth Observations, from Weather data or from laboratories that analyse and geo-trace products detecting specific isotopes that are present only on certain countries or regions. Blockchain can contribute to democratize access to these specific and expensive data, instead being used only by large corporations.

If this is true in agriculture, with the advent of Industry 4.0, each product can also be fully traced along its transformation, packaging and, once more, transportation to retailers, supporting information to consumers and consumer evaluation/recognition along the Food Supply Chain. Large retailers (WalMart) and food producers (Nestle, Dole, Golden Food) are exploring for a couple of years (since at least 2016) the opportunity to use Blockchain (namely IBM Hyperledger) to provide traceability along the Food Value Chain (Xiong, et al., 2020). This trend is also being followed by Retailers in Europe like SONAE or Auchan.

In (Zhao, et al., 2019), several use cases are mentioned where Blockchain technology is being paired with RFID/NFC technologies to provide secure and transparent information across the value chain – including production, transportation, transformation and even water management. These authors present some uses cases which may inspire some concrete applications:

- Tuna Tracking and Certification (Provenance)
  Provenance system ensures the transparency along the value chain, providing information to all peers in the process. The system collects information from fishing (location) but also relies

on previously tagged tunas to ensure sustainability of origin and that tunas' transportation and storage are compliant with standards. All the information is persisted in a Blockchain and Smart Contracts are used either to perform payments or compensations (if the product quality is not adequate).

- Olive Oil Tracking (Ambrosus)
  Olive Oil is one of the products which is being selected quite often to implement blockchain-based solutions due to its high value and, also, to the frequent counterfeiting in multiple stages of its production and distribution.
  Ambrosus solution was developed for Olive Oil industry in France (although others are used in other locations like Italy) and collects information entered manually by the producers or collected from sensors. Ambrosus' solution uses a sensor that analyses phenolic compounds, oleic acid, and α-tocopherol in combination with and RFID tag. The sensor is included in a smart package , assembled in a RFID tag or in bio-tracers are inside the packaging. The system interacts with the sensor and records certificates into the blockchain (in this case Ethereum-based) and the consumer may access information by scanning a QR-Code.
- Wine Blockchain (EZ Labs)
  Wine Blockchain is a project of the Italian company EZ Labs that aims at using Blockchain to provide traceability and ensure authenticity of Wine. This means, for example, being able to ensure that it was produced from grapes of a certain region, fighting adulteration and forgery of Italian Wines. It uses a similar approach to the previous one by introducing a QR Code in a label and registering all data collected by hardware or using software in a blockchain. They have launched a platform AgriOpenData where all the information is stored allowing end-users to verify the geographical context, the cultivation process, the winemaking process as well as distribution and sale.

Complementing these examples, (Antonucci, et al., 2019) adds some other uses cases:

- Coffee
  Coffee is a product where its characteristics are inherently linked with its provenance and roasting process, holding a relevant market value. Blockchain is used to ensure reliability and to prevent modification of documentation covering the process from crops to the brewed coffee cup.
- Beef
  To eliminate food fraud, cattle is labelled, and information related to production and transformation is recorded in a blockchain allowing users to validate all the steps including genealogy, breed, geographic context, handling, slaughtering, cutting, processing, and transportation. In fact, geographical provenance and breed have a relevant impact on the meat price.
- Beer
  Downstream beer is the first beer product using Blockchain to reveal information about ingredients and brewing process.
- Fresh Food
  Information on product origin and transportation using sensor data, allowing full traceability from fark to fork.
- Milk
  To avoid frauds in dairy supply chain (especially when in butter or cheese production), Blockchain solutions automates acquisition and registration of information along the full process.

- Pasta
  Pasta quality is related with factors like flours (and other ingredients), type of drying, and transportation. Especially in Italy, origin of grains and grinding process are paramount to attain a high-quality product.

Still in Agriculture, the combination of valuable data from production and context (like weather conditions) is allowing insurance companies like WorldCover (https://www.worldcovr.com) or Arbol (https://www.arbolmarket.com) to provide simplified and non-repudiable crop insurances based on dynamically assessed risk and in attracting novel investors to this arena (Xiong, et al., 2020). Also, especially in developing countries, access to a recognized currency is quite difficult and there are many initiatives appearing that rely on cryptocurrencies (Bitcoin and others) to pay to farmers (and, also, supplying them seeds, tools, and other goods in closed marketplaces).

4. Acceleration Programmes

According to the European Commission (Nascimento, et al., 2019), in between 2009 and 2018 the investment gap in Blockchain is still led by the United States accounting for 33% of total volume of 4.4 billion euros, followed by the European Union with 22% and a total of 2.9 billion euros and by China with 21% and a total amount of 2.8 billion euros. As part of Horizon 2020 funding support the Commission as launched a Pre-Commercial Procurement action to prepare the launch of EBSI - European Blockchain Services Infrastructure – that will provide cross-border digital services and is now currently available for testing in countries members of the European Blockchain Partnership.

Included in these strategic actions, some Blockchains acceleration Projects like Block.IS https://blockis.eu/), BlockStart (https://www.blockstart.eu), BlockPool (https://blockpool.eu), Blockchers (https://blockchers.eu), Ontochain (https://www.ngi.eu/ngi-projects/ontochain), LEDGER (https://ledgerproject.eu/), among others. All these projects were supporting financially, mentoring, and engaging start-ups with potential customers or implementing pilots, as explained in the following table:

Table 1: Accelerator programmes in Blockchain related topics

Project Name	Funding Scheme	Domains/Topics	Objectives
Block.IS - Blockchain Innovation Spaces	H2020 INNOSUP-01-2018-2020 Cluster facilitated projects for new industrial value chains	• Agri-food • Finance • Logistics	Block.IS is an acceleration programme that aims to build an open and collaborative cross-border, cross-sectoral innovation ecosystem that fosters the use of blockchain technology in three vital sectors for the European economy: agri-food, logistics and finance. Block.IS accelerator supports SMEs and start-ups from the ICT sector all the way from ideation to commercialisation offering them tailored business and technical support as well as direct funding.

Project Name	Funding Scheme	Domains/Topics	Objectives
BlockStart – Boosting SME uptake of blockchain technology	H2020 INNOSUP-03-2018 Blockchain and distributed ledger technologies for SMEs	• Retail • Finance • ICT	BlockStart project aims to help SMEs strengthen their competitive positions using distributed ledger technology (DLT). The project has two key work streams: • identifying 15 DLT solutions to be demonstrated; • identifying 60 SME to run the demonstrations. These activities will be based on Open Calls and DLT solutions will be subjected to various evaluation stages. It will also encourage intermediaries to develop expertise through training sessions on DLT support services.
BlockPool - Pooling SME adoption and deployment of Blockchain and other DLTs	H2020-INNOSUP-03-2018 Blockchain and distributed ledger technologies for SMEs	Financial & Insurance Services Energy, Utilities & Raw Materials Industrial Products, Agriculture & Manufacturing Government & Smart Cities Transport & logistics Social Good Healthcare Retail, Consumer & Media	Blockpool main objectives are: Develop a common vision and framework to support the uptake and diffusion of Blockchain and other DLTs Demonstrate the use of Blockchain/DLTs in a testbed of 25 SMEs on different sectors. Build upon the project's experience to derive lessons for intermediary organizations, policy makers and regulators. Contribute to the streamlining of the Blockchain/DLT's technological, economic and legal environment to improve framework conditions for their diffusion. Build intermediary organisations' capacity across value chains and sectors to enable Blockchain/DLT diffusion and deployment.
Blockchers - BLOCKCHAIN TECHNOLOGIES FOR SMEs	H2020-INNOSUP-03-2018 Blockchain and distributed ledger technologies for SMEs	Industry 4.0 Mobility & Transport Food & Retail Media Legal & Compliance Health Others	The main objective of BLOCKCHERS is facilitating the usage of Distributed Ledge Technologies (DLT) across SME in Europe thanks to the promotion and support of DLT sub-granted use cases in multiple sectors by SME, support on the creation of a "smart" regulatory framework for the EU and the development of policy recommendations. Blockchers' open calls will select SMEs developing solutions with DLTs for validation in end-users SMEs use cases. Based on the outcomes, recommendations and best practices will be elaborated for promoting the uptake of DLTs in different sectors. BLOCKCHERS is implemented through a 4-stage process: open call – immersion – implementation – recognition, that allows the adaptation of the technology to the use case, its implementation and validation in real use case scenarios, while facilitating the elaboration lessons learned across several verticals to extract recommendations and best practices.

Project Name	Funding Scheme	Domains/Topics	Objectives
LEDGER – decentraLizEd Data Governance for nExt geneRation internet	H2020 ICT-24-2018-2019 Next Generation Internet - An Open Internet Initiative	• Health • Finance • Media • Public Services • Energy • Open Disruptive Innovation	LEDGER goal is to make of data a common good owned by citizens where the wealth created by data-driven platforms is equally distributed. To achieve this moon-shot LEDGER promotes and support the creation of minimum viable products (MVPs) where privacy by design, openness and data governance are at the core of their proposition. LEDGER offers to the selected projects: • Equity-free funding • A venture builder programme for up to 12 months with business mentors, camps, technological vouchers, training and demo days. • An expert researcher in residence to support the selected teams along the full programme. • Access to market and support to raise further investment for the best projects in class.
ONTOCHAIN – Trusted, traceable and transparent ontological knowledge on blockchain	H2020 ICT-54-2020 - Blockchain for the Next Generation Internet	• Applications • Semantic Interoperability • On-chain data management • Off-chain knowledge management • Ecosystem Economy • Ecosystem scalability and integration	ONTOCHAIN will provide funding to internet innovators for developing Blockchain-based knowledge management solutions that address the challenge of secure and transparent knowledge management as well as service interoperability on the Internet. ONTOCHAIN will support innovators (academia and high-tech companies) in the conceptualisation, development, experimentation, and integration of new Blockchain and Distributed Ledger Technologies that aim to preserve the integrity and reliability of information and content. A wide network of Blockchain Experts will provide coaching mentoring and training in business and Blockchain related topics to achieve the common goal of delivering a software ecosystem for trusted knowledge management.

Under Block.IS project, several projects related with Agrofood and Logistics were supported like:

- Zelena Točka, a company running a distribution centre to promote short supply chain of vegetables and local products;
- Trace Labs, a company that started using Blockchain in 2016 to ensure trusted data exchanges namely and traceability for food processing companies and which has implemented a network protocol (Origin Trail) and a Network Operating Systems (nOS) to seamlessly integrate legacy systems in blockchain and provide full traceability and data exchange;

- Phy2TRACE, a company which develops data management and traceability platforms for functional food industry and cosmetics;
- ELMIBIT a company which develops Smart Agriculture solutions including e Vineyard and eOrchard;
- ASN that provides business monitoring solutions to perishable goods supply chains;
- Art21 that is working with AI, data analytics and Blockchain and integrating with spectrometry enabling tracking the contents of the food product itself;
- Apio, an Italian company that has implemented a food traceability solution based on Hyperledger to track tomatoes from production to consumers.

BlockStart project has also supported companies financially, provided mentoring and matched start-ups with SME (and Corporates) to develop a prototype of their blockchain-based solutions:

- IBISA developed a platform for mutual and insurers that leverages Blockchain and Earth Observation satellites' data to enable micro-insurances for agriculture in digital, simplified, and cost-effective way;
- Sensefinity is a start-up that develop a solution that integrates sensors, NB-IoT communications, machine learning techniques and blockchain to monitor Cold-Chain transportation (quite relevant at this time to distribute CoViD-19 vaccines although it was created to track food products);
- Cropt, which has developed a prototype for an Agricultural Crop Insurance using AI and Blockchain.

BlockPool project is also supporting with mentoring, training and grants a SME using Blockchain in Agriculture and Food Chain: SIA Kedeon Solutions is also developing a blockchain solution to make the cold chain more secure, transparent, and trusted.

Complementary to these funded projects, there are some other initiatives aiming at supporting the creation and development of Blockchain initiatives, namely linked with Blockchain implementations or specific scenarios (like FinTech).

Concerning Blockchain initiatives, R3 (https://www.r3.com) linked with Corda Platform has setup a Venture Development Ecosystem that includes early-stage support for DLT projects (Launchpad) and Incubator + Accelerator programs targeting following stages. Although the program does not provide funding directly, it allows start-ups to interact with sales and marketing teams; a network of coaches, advisors and mentors; investors and participate in community events.

Concerning vertical and specifically Fintech, the Central Bank of Lithuania (https://www.lb.lt) promotes one of the most dynamic initiatives, aiming at attracting Fintech companies to install in Lithuania (one of the most known is Revolut). Their support includes access to:

- Newcomer Programme - the regulator helps potential newcomers in assessing their ideas, provides insight on legislative and licensing requirements for businesses aiming to start their activities;
- LBChain - the world's first-of-its kind blockchain sandbox developed by a financial market regulator. It combines regulatory and technological infrastructures as well as allowing market participants to test their business solutions in a controlled environment;

- Regulatory Sandbox - allows potential and existing financial market participants to test financial innovations in a live environment under the guidance and supervision of the Bank of Lithuania;
- Regulatory Technology - promoted technological development in the financial system by creating added value for consumers of financial services and financial market participants, helping companies creating solutions based on real needs (refined in discussions with the financial market, representatives of the information technology, academic community, the public sector);
- Digital collector coin (LBCOIN);
- Open Banking - a system based on application programming interface (API) and intended for sharing financial information necessary for the development of financial products and services.

Besides these activities, sometimes involving third-party support, it also noticed that the Central Bank of Lithuania is one of the first market regulators to providing guidelines on Security Token Offering (STO) which contribute to add regulatory clarity and higher investor protection. It is important to mention that Security Tokens can be applied to the Agri-Food sector, supporting transactions of goods securely and transparently in comparison to the current Soft Commodities Trading market practices.

5. Opportunities

(Nascimento, et al., 2019) intends to present the state of the implementation of Blockchain solutions and investments as well as highlight some future trends that may be addressed by the existing European Artificial Intelligence and Blockchain Investment fund or that should be tackled by the next generation Framework Program.

In the public sector, the European Blockchain Partnership (https://ec.europa.eu/digital-single-market/en/news/european-countries-join-blockchain-partnership) is driving the implementation of cross-border digital public services through the establishment of the European Blockchain Services Infrastructure (EBSI) (https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/EBSI) and an initial funding of 200 M€, namely through CEF Digital Programme, Horizon 2020 and the AI and Blockchain Investment Fund (managed by the European Investment Bank) part of the InnovFin Equity instrument (https://www.eif.org/what_we_do/equity/single_eu_equity_instrument/innovfin-equity/index.htm).

The European Commission (through DG CONNECT) started a Pre-Commercial Procurement process aiming at developing and validating prototype implementations in a real scenario, four main uses cases:

- Notarisation: Leveraging the power of blockchain to create trusted digital audit trails, automate compliance checks in time-sensitive processes and prove data integrity.
- Diplomas: Giving control back to citizens when managing their education credentials; significantly reducing verification costs and improving authenticity trust.
- European Self-Sovereign Identity: Implementing a generic Self-Sovereign Identity capability, allowing users to create and control their own identity across borders.
- Trusted Data Sharing: Leveraging blockchain technology to securely share data between authorities in the EU (e.g. IOSS VAT identification numbers and import one-stop-shop (IOSS)) amongst customs and tax authorities in the EU.

Although this initiative is driven by public authorities, some of these use cases are enablers of private applications (like for example, Notarisation or Self-Sovereign Identity). The call for tenders (https://etendering.ted.europa.eu/cft/cft-display.html?cftId=6507) identifies some key use cases related with Agri-food and Supply Chain like:

Support the development of circular economy and the exploitation of digital product passports enhancing the traceability and circularity of all goods on the EU market;

- Traceability of products for limiting counterfeiting (for example, high-valued agri-food goods);
- Proving the origin and conditioning of product in <food and Agri chains;
- IoT-enabled customs item tracking and other IoT apps, such as real-time tracking of the geo-positioning and system status of fast-moving objects across frontiers.

Furthermore, one of the call objectives is to develop different sustainability models based, for example, in cost sharing with end-users as a complement of a fully publicly funded Blockchain infrastructure. EBSI, currently, is based on a combination of public (permissionless) and private (permissioned) Blockchain implementations, creating a Hybrid scenario. The selected implementations were the Ethereum Enterprise (https://entethalliance.org/) using Hyperledger Besu Client (https://www.hyperledger.org/use/besu) and Hyperledger Fabric (https://www.hyperledger.org/use/fabric). Yet, during the implementation of PCP Contract, other alternatives can be explored to improve security and scalability.

Moreover, aside from financial applications, Blockchain is considered to be "one of the breakthrough technologies which can have a huge potential impact in the financial sector, but also far beyond", enabling digital services, eHealth, Social Goods delivery, IoT and supply-chains among others. (Nascimento, et al., 2019) highlights Blockchain impact in transforming industry, trade, and markets (Trade and Supply chains, Smart Manufacturing, Energy Systems, Digital Content, Health and Pharmaceuticals) as well as government and the public sector.

The next Framework Programme (Horizon Europe), the Digital Europe programme and the Recovery and Resilience Facility will continue supporting research and innovation in a traditional way but will also create or support instruments like Investment Funds and Acceleration Programmes to help breaking existing gap between Europe and remaining economic blocks in this topic and in its relationship with enabling technologies like Artificial Intelligence.

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