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The usage of blockchain in agri-food value chains: State of the art in Spain and an analysis from public perspective

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The usage of blockchain in agri-food value chains: State of the art in Spain and an analysis from public perspective

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ABSTRACT

On November 2021, the European Parliament ratified the Common Agricultural Policy (CAP) reform that will be applied from 2023. Among other issues, the (re)structuring of the sector will be promoted throughout a strengthening of the position of producer organizations in the value chain. If met, the objectives of the CAP will imply a change in the production model simultaneously requiring a sustainable environment while increasing efficiency for the farms and their associated companies to remain profitable. In Spain, in 2019 the adoption of new technologies for the digitization of this productive sector was already presented as part of the solution targeting the structural problems of Spanish agri-food companies: lack of competitiveness and innovation, lack of automation, as well as to alleviate regional disparities. Since then, the situation has been aggravated by the low rate of investment (both public and private) dedicated to research and development, as well as the scarcity and inadequacy of technological capabilities, especially by agri-food SMEs. At the same time, within this lackluster scenario, some of the technologies key to the Spanish agri-food sector, such as those related with blockchain and used for food control and traceability have experienced a significant progress. In fact, the usage of blockchain within the supply chain management is almost doubling year-on-year. Within this context, this paper investigates which is the level of development of blockchain technology in the agri-food sector in Spain and how it is supported from public policies using a methodology that blends interviews with key representatives of the value chain with an examination of available, mostly grey, literature. From the analysis, the paper concludes that blockchain deployment has entered a stage of early maturity in supply chain tracking. However, its adoption in traceability in this same value chain displays considerable challenges with a relatively high number of pilot and test projects being deployed in the last years, but still lacking a sound analysis of the results achieved. Among the challenges, the paper highlights the appropriateness of data registered in blockchain and the selection and set up of scalable -mostly de facto- standards. Automation of data capture and combination of blockchain with other technologies such as RFID and AI also required further developments. From the public perspective, beyond economic incentives, the reusage and integration of the same data used in blockchain into the European public registries for agri-food control could be a significant contribution to set up scalable “de facto” standards and, from here, contribute to the adoption of this technology.

1. BACKGROUND

As part of the objectives of economic sustainability of the sector, the European agricultural policy (PAC) ¹ encourages an intelligent restructuring of the sector from the producer organizations, so that these extend to areas of greater value in their supply chain and result in a more balanced distribution of this same value.²This value capture is not possible without a digital

¹ A key objective of CAP is “the enhancement of market orientation and increased competitiveness, including a greater focus on research, technology and digitalisation”. Digitalisation is seen a driver for achieving the European green deal, reinforcing Europe's resilience by halting biodiversity lost and building a healthy and sustainable food system. https://ec.europa.eu/info/food-farming-fisheries/sustainability/economic-sustainability/cap-measures_es

² https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_es

transformation of the small and medium-sized companies that make up the majority of the production sector of the agri-food industry (Gobierno de España, 2021). Likewise, from the point of view of the growing demands of consumers, the restructuring proposed in the new CAP approved in November 2021 is committed to the incorporation of technological innovations that would allow differentiating those products that meet European production requirements from the rest of food supply, and that also provide greater transparency³ about its origin, transactions and agents involved in the supply chain. The origin of this new role for technology in the field of agri-food can be traced back to 2019, when 24 European countries signed the Declaration on "A smart and sustainable digital future for European agriculture and rural areas" (Council of the European Union, 2019), where this double mission - economic and environmental sustainability - for new technologies was collected: "*technologies such as Artificial Intelligence (AI), robotics, blockchain, High Performance Computing (HPC), Internet of Things (IoT) and 5G have the potential to increase farm efficiency while improving economic and environmental sustainability. Such technologies can transform all types of farming and enable better decision making*"

Among all these technologies, this article focuses on blockchain technology. The reason is none other than some of its main properties (Degli-Esposti & Arroyo, 2021)-- anonymization, proof of tampering and auditability - seem particularly useful to increase confidence in the information required in terms of food safety, improve its traceability, prevent fraud, and provide of transparency on certain production conditions to consumers or end users. This is, therefore, the central research question of this article: to know where, how and why blockchain projects are implemented in the agri-food sector, what difficulties they face and how they can be solved from the field of public policies. It must be taken into account that, in applications other than its fintech origin (*White paper*. 2022), this technology appears to be ideal for improving the transparency of supply chains and, in particular, in practical cases belonging to the agri-food field (Berneis, 2021).

Blockchain has been revealed as a useful tool to secure the data inherent to products where a relevant part of their value lies on the conditions in which they were produced (organic production), health controls that were carried out or their origin (European & Commission, 2020) or data inherent to the conditions required of producers and that differentiate the product before the operators and the consumer. In fact, this technology has experienced great progress in the agri-food industry (Chang et al., 2020). and especially during the Covid-19 crisis and in certain regions of the world, such as China, which had optimal conditions for its development and implementation (Kamilaris et al., 2019). For example, during the period 2019–2025, blockchain technology in the logistics market is expected to grow at an annual rate of 82% (Chang et al., 2020).

In Spain, the agri-food industry is the most important industrial subsector with a value of 107,000 million euros generated in sales, which represents almost a quarter of the entire Spanish manufacturing industry. This sector generates 19% of all Spanish industrial employment. In addition, Spain is the 8th largest agri-food exporter in the world and the 4th in the European Union, with 53,179 million euros exported in 2019 (Ministerio de Agricultura, Pesca y Alimentación., 2021). At the same time, it is a sector in need of renewal and a profound digital transformation, despite the Spanish agri-food sector has a lower cost structure than its European neighbours and competitors⁴. However, the size of the companies is also smaller, which makes it difficult to compete on a large scale. This situation raises two complementary alternatives: the sector must make use of its capacity to innovate and extract value from what

³ https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en

⁴ <https://www.expansion.com/economia/2020/10/06/5f7b7d33468aeb5e1d8b45d3.html>

it already produces, and it must unify the value chain to make it more sustainable, as well as to invest in raising awareness of the Spain brand.

Likewise, the evaluation of the interest and potential of the incorporation/appropriation of an incipient technology such as blockchain technology to a traditional and mature sector of the Spanish economy such as the agri-food sector can be very useful, not only to evaluate the potential of its implementation, but also to assess how public policies to promote the digitization of Spanish companies have influenced its implementation.

However, the information available on relevant projects for the implementation of blockchain in the Spanish agri-food sector is very scarce, so an additional objective of this research is to know, collect and study practical examples of these solutions in Spain. In addition, the underlying reasons for the low deployment of these projects will be analysed, that is, if the low introduction of this technology is the result of ignorance of the agents or, on the contrary, it is due to the existence of difficulties of applicability in practice due to issues related to connectivity, lack of infrastructure or insufficient digital skills.

The following section will describe the process and conclusions from the review of the available literature on the deployment of blockchain technologies in the agri-food sector that has been carried out. The focus has been placed on those specific articles that referred to the use of this technology to certify the production conditions of food or raw materials throughout the supply chain. From here, the following section explains the methodology used. Next are the discussion and results from the analysis. A section on conclusions closes the paper.

2. GENERAL REVIEW OF THE APPLICATIONS BASED ON BLOCKCHAIN TECHNOLOGY FOR THE AGRIFOOD SUPPLY CHAIN TRACEABILITY.

2.1 Literature review on blockchain and agri-food industry

The specific bibliometric studies on the food and agricultural industry made in the context of this article show how the applications of blockchain technology began in 2016 and continued to receive increased attention from academics, particularly from 2019 (Niknejad et al., 2021a) (Chang et al., 2020). In addition, the results of the bibliographic research also show that India, China and the US are the countries where the most articles appear dedicated to the application of blockchain solutions to the food chain. It should also be noted that, in general, the results of the bibliographical research show how developing countries have devoted more attention than others in their scientific articles to blockchain technology in the agri-food field, probably in direct relation to the weight of the agri-food industry in their economies.

Perhaps the most relevant compilation of deployment cases is that made by the Food and Agriculture Organization (FAO) in its publication "e-agriculture in action: blockchain for agriculture" (Berneis, 2021), where several applied examples are documented to agribusiness: insurance, land identification, water treatment or forest transformation processes. However, few is said on the use blockchain technology to secure production data throughout the supply chain, specifically in the agri-food sector. In this regard, the scientific literature (Tripoli & Schmidhuber, 2018) begins by presenting the limitations of blockchain technology for scalability and those related to its use to prove production conditions. However, the most recent scientific literature is beginning to examine "consolidated" applications in the agri-food supply chain, for example as a means of payment (Nihit Choudhary, 2020), or to control batches of origin and transport time (Yohan et al., 2022). However, its usefulness to safeguard data related to production conditions throughout the supply chain of a product still presents many challenges (Srivastava & Dashora, 2022a).

Regarding the volume of scientific production, the number of articles dedicated to blockchain technology has increased, especially in 2019 and 2020, probably due to the development of

applications based on permissioned blockchain systems that have given rise to new generations of Distributed Ledger Technologies (DLTs) (Romero-Frías et al., 2021), and also due to further development in 2020 during the Covid crisis, to control the supply chain.

On the other hand, this international scientific production on generic blockchain began to decrease as of 2020. In 2021, the paper has found a new strand of studies that present technological solutions based on different DLTs (Hyperledger, R3, IBM Blockchain, Ethereum or Stellar) to ensure traceability within the supply chain, but so far the practical applications of the use of this technology aimed at guaranteeing production conditions often do not go beyond a pilot project or have lasted for a very limited number of trials. Some authors agree on the limitations of existing solutions in terms of number of transactions per second and scalability (Romero-Frías et al., 2021) (Srivastava & Dashora, 2022b).

2.2 Review on regulations in the agri-food industry relevant to blockchain

From the content of the scientific publications that appear in both geographical areas, it seems that in Western countries, and especially in Europe, the interest of this technology applied to ensuring the origin and production conditions of food and its healthiness is less relevant than in Asia, although Europe is developing a series of guarantee seals aimed at certifying origin, environmentally sustainable production conditions and other factors such as production working conditions.

This lesser interest in food safety may be due to public official control systems in Europe, which are largely aimed at guaranteeing origin as well as food safety from a health point of view. In this regard, a compilation of control/monitoring regulations and standards has been included in the Annex. This, without being an exhaustive list, describes an extensive collection of regulations applicable to agricultural operations, fishing, and official food controls.

For example, in the case of fishing, the VMS tracking system for fishing boats has been in force since the 1990s and catch certificates in 2010. The EU's General Food Law entered into force in 2002 and makes traceability compulsory for all food and feed businesses, comprising a complex system of official controls. These initiatives have been complemented with electronic registration systems for imported food and computerized and electronic means of registration and control. In Europe there is also an extensive system of additional rules on labelling and guarantee seals, so that, in general, in Europe the consumer has a health and origin assurance system that is already largely covered by the public control system⁵ (Zhang & Bhatt, 2014). The *acquis Communautaire* in this matter is perhaps the most complex, but it is not the only one. In fisheries, for example, there are equivalent initiatives in other Western countries such as the US seafood import and monitoring program and COOL (Country of Origin Labelling) laws.

Even though in Europe there is a robust official control system for production and traceability, the data collection of the control system is not entirely transparent to the consumer.

Official regulations coexist with multiple market initiatives, from those offered by NGOs, such as certifications, eco-ratings, aimed at improving traceability and other useful stamps in many cases when the productions integrate food or raw materials from different origins or there may be counterfeits. These “private” applications are not standardized, not all technology providers integrate the same data or do it in the same way, and there are several academic references to the need to incorporate the sharing of crucial data or undertake verification of the integrating data manually and also we can find several academic references underlining the needs to integrate the robust and relevant data in the system (Xiong et al., 2020) (Hernández San Juan, 2022).

⁵ <https://www.betelgeux.es/noticias/europa-lider-trazabilidad-alimentaria/>

2.3 Review on the implementation of blockchain in the agri-food industry.

Consistent with the above and in practice, companies that offer solutions to provide traceability to agri-food products and that use Distributed Ledger Technology (DLT) have been increasing significantly, especially since 2018. During 2020, the pandemic has driven an explosion of investments in supply chain management technology, mostly connecting downstream operators such as processors, distributors, verifiers, and also other functionalities such as payment applications, for example Full profile⁶, Heifer⁷, or FIE⁸ (Vaghani et al., 2022) (*Gartner Blog Network.2022*).

However, despite companies' prospects, there are several references both in scientific papers (Vaghani et al., 2022) and informative articles (*Gartner Blog Network.*) who speak of "blockchain fatigue", derived from the fact that many of the projects remain in a pilot stage due to the lack of standards, the lack of convergence of technologies, immaturity, the problem of scalability, of interoperability, an overly ambitious scope, and a lack of understanding of how technology could help solve the problem at hand.

By sectors, within the agri-food field, although there are quite a few feasibilities analysed, there are few examples in the scientific literature in which the use of blockchain has translated into solutions that can be consolidated by providing true added value. Due to its appearance in the bibliographic citations, the best-known case is probably the aforementioned BC platform created between Walmart and Hyperledger and the IBM Trustchain projects (which is no longer in use).

These experiences pioneered the emergence of third-party services called BAAS (Blockchain as a service), which offer functional platforms that can be adapted to customer needs. Currently there is a large number of companies that offer these services (Microsoft, IBM, Oracle, Amazon, Alibaba, SAP, Accenture, Baidu, Huawei, Kaleido Hewlett-Packard Enterprise) (Jesús Alfonso & Muñoz Jiménez, 2020) and some have developed specific solutions for the agri-food sector⁹ (Berneis, 2021). Based on the analysis carried out in this study and within the agri-food field, IBM's "Food Trust" seems to be the only scaled-up project that is in production¹⁰. (*Noticias Carrefour. 2018*) (Cargill., 2018) (*Mediterranean Olive Oil Producer Uses IBM Blockchain to Fight Food Fraud. 2020*).

By sub-sectors, the fishing industry has been one of the most active in the development of software solutions based on DLT technologies to offer certification systems / product guarantee seals (authenticating aspects related mainly to the origin / its handling / and the time) to gain consumer trust. In the fishing field, it has been possible to identify twenty references (of informative articles) that refer to the use of blockchain to guarantee their product, but in

⁶ (Agridigital), <https://www.fullprofile.com.au/>

⁷ <https://www.heifer.org/campaign/2019/blockchain-initiatives.html>

⁸ (FLETCHER International Exports) <https://www.fletchint.com.au/the-fletcher-group>.

⁹ The best known are the current Food Trust (IBM), in principle it was an alliance between the DOLE companies; DRISCOLL'S; GOLDEN STATE FOOD, KROGER, McCormick, McLane, NESTLÉ, TYSON FOODS, UNILEVER AND WALMART to address food safety and to ensure traceability in the face of contamination, then it has been used to present proof of concept focused on specific solutions for SMEs related to some actors. Other famous blockchain system is SAP, used by the company Bumble Bee Foods used for documenting the traceability of tuna from Indonesia. (Berneis, 2021)

¹⁰ The IBM system has been used for Carrefour's free-range chicken projects (*Noticias carrefour.2018*), Cargill's Turkey (Cargill., 2018) or CHO olive oil (*Mediterranean olive oil producer uses IBM blockchain to fight food fraud.2020*) one of the most important producers of Italian olive oil. In these procedures, different process quality points were used, which could be traced using this blockchain technology.

practice few providers of "solutions or seals" have been consolidated in a stable manner. Some of those currently operating are listed in Table 1 (see Annex).

As of 2020 and as new DLT architectures appear, many scientific articles (Berneis, 2021) present as a challenge that these DLT systems exchange truthful, accurate and validated data and also their usefulness, which translates into an academic interest in the analysis of external inputs (gateways) and oracles, that is: how to introduce external data on the network. The most recent articles give more and more importance to artificial intelligence to manage external data without human intervention or through data verification.

Likewise, the relevance of the information is also analysed: to what extent these data are pertinent to certify relevant information for the consumer (for example, identity, production conditions, etc.), and which is the role and status of standards. Another of the issues in question that has been considered of interest is the added value of the use of these systems for the producer, which seems to only occur in products of particular value for the producers where the existence of counterfeits is a problem.

We can also find several articles that propose mixed systems (data collection using sensors IOT¹¹ + blockchain) (Akhtaruzzaman Khan et al., 2022) to ensure data integrity (truth and immutability). The objective is to improve the integration of the information, derived from the production conditions, which is stored in a blockchain system, an improvement over other systems that are based on information provided through declarations that do not have sufficient audit guarantees. and supervision.

In this regard, there is a scientific interest in controlling the gateways or developing standards (on the collection and inclusion of data or its certification) that guarantee that the chain of blocks not only makes the information immutable but that what is recorded through the blockchain is accurate, adequate, and relevant information for the purpose to be certified. It should be noted that, regarding this "purpose", not all applications integrate the same data or pursue the same objective. Several international projects of interest have been identified from the bibliography (see Table 4 in the Annex).

In terms of research, in Spain there have been some contributions to the literature about the theoretical application of blockchain in the agricultural sector, focusing on food traceability issues (Mirabelli & Solina, 2020)but, as can be deduced from this bibliographical review, the scientific literature has not yet answered the question of what the situation of the implementation of this technology in Spain is, what challenges does it face, what potential exists to apply these new developments in supply chains agri-food supply, and what is its role in ensuring the conditions of food production throughout this same supply chain.

Also, both in Spain and internationally, there is hardly any information on public policies and the use of public or public-private financing mechanisms to contribute to the deployment and adoption of blockchain technologies in the agri-food sector.

In this regard, the starting hypothesis of this work is either because there are structural problems or because the traceability assurance system through official controls makes it unnecessary, although Spain has favourable starting conditions - both in terms of access to financing and the availability of technology-, the blockchain solutions developed to date in the Spanish agri-food industry are not being consolidated, despite their obvious usefulness in offering added value and differentiating certain agri-food products.

3. METHODOLOGY.

¹¹ Capture information automatically (temperature, location, humidity level) by a measurable electrical signal.

For this article, the methodology used desk research and field work carried out through semi-structured surveys.

3.1 Desk research

The article uses the results of a bibliometric analysis carried out using the SCOPUS database on the food and agricultural industry in search of innovative applications based on blockchain technology in the food industry from 2020 to 2022. The research method has been inspired by approaches similar in the literature (Mazzù et al., 2021), (Stranieri et al., 2021), (Niknejad et al., 2021b), (Barbosa, 2021).

The search pattern applied was the following: "BLOCKCHAIN and FOOD or AGRICULTURE" and "BLTD + FOOD OR AGRICULTURE" between the years 2020 and 2022 as depicted in Exhibit 1.

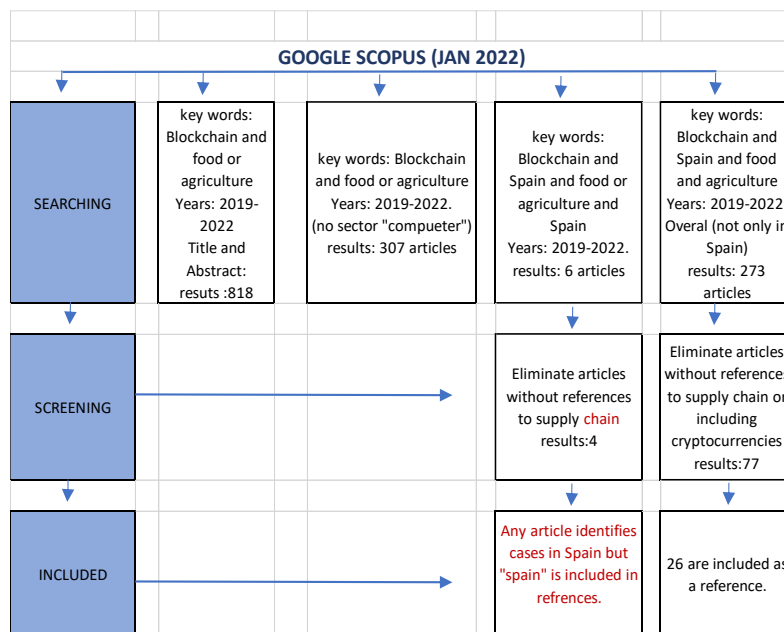


Exhibit 1. Search pattern and results for blockchain and agri-food industry

The bibliography extracted from the academic sources identified through Scopus was considered insufficient to know the real situation of blockchain technology in Spain. Therefore, the review was completed with commercial publications and reports using the data bases of the bibliographic collections and journals of the Spanish Ministry of Agriculture and its associated bodies. Subsequently, new Spanish bibliographic sources cited by the agents interviewed were identified -such as master thesis and other professional reports- and, finally, the initial bibliographic analysis was revised again using an alternative bibliographic repository through Google Academic.

In this second search, the filtering of the results could not be reproduced with the same search pattern due to the limitations of the repository, which does not allow discrimination by thematic areas, although the same keywords were used. Due to limitations in the search engine, the filtering of relevant results was done by analysing the results case by case. In addition to grey literature from previous steps, five new academic papers were added to the results.

3.2 Survey design and stakeholders identification

From the literature review, it was found that, although there are many examples of the application of blockchain to the supply chain, there are very few practical examples that analyse

the integration of agricultural production data as part of the creation of value. For this reason, the paper uses semi-structured interviews to contrast and validate the information obtained from the bibliographic search regarding the current use of blockchain in Spain applied to the agri-food supply. This methodological approach is similar to others available in the literature on the introduction of new technology applications (Patelli & Mandrioli, 2020), and, in general, semi-structured interviews are considered an effective tool to explore the opinions of respondents and collect in-depth data on complex issues (Nienaber et al., 2020). In fact, this method has recently been used in articles focusing on blockchain and food chain value creation and to investigate the attitudes and decision-making of farmers and other stakeholders associated with agricultural issues (Chang, V. et al., 2020); (Q. K. Nguyen, 2016); (Ferreira et al., 2021), (Sheila Barry & Sheila Barry, 2021).

Regarding the choice of relevant stakeholders the paper includes providers of technological applications of blockchain, regulatory agents and academia in the field of new technologies applied to traceability (Sheila Barry & Sheila Barry, 2021). This choice is in agreement with previous studies where similar semi-structured interviews have also been conducted with representatives of these interest groups, with the aim of identifying a range of perspectives on the factors that underline transparency and added value within the entire food supply chain (Stranieri et al., 2021). In the case of this paper, special attention has been paid to examining the determining factors that lead to deciding to adopt the use of blockchain in those cases that integrate agricultural production conditions and the influence of external financing in decision-making.

To prepare the questionnaire, the paper as departed from available surveys (Pettersson, 2005) (Nienaber et al., 2020), adapted to the agri-food field, although the combination of the above questionnaires taken already offered an suitable set of relevant questions applicable to this research. The questionnaires are collected in the Annex in their original Spanish format.

3.3 Selection of respondents and cases

The selection of respondents started with a map of agents identified from professional magazines and from the directories/agenda of the public administration and universities. A second identification of agents was made through the application of the European Commission "transparence register EU", a database that lists the organizations that try to influence the law-making process and the implementation of policies of the institutions of the European Union. Through this database and introducing the terms "blockchain" and "Spain," a second series of agents working with blockchain solutions in Spain were identified (see Table 2 in the Annex).

From here, the same respondents helped to identify a second level of stakeholders following the "snowball sampling" technique, used when the individuals that compose the sample are very limited (Mark Easterby-Smith, Richard Thorpe, Paul Jackson, Andy Lowe,). Thus, in the first phase of the investigation, 14 interviews were conducted with experts from the five relevant areas of the logistics chain (the percentage of valid responses was 23%¹²) and with representatives of the providers of technological solutions and public administration. In the second stage, another six interviews were derived from the recommendations (the percentage of valid responses was 60%). Snowball sampling was complemented with direct exchanges through the "LinkedIn" social network. In total, 60 were identified, 44 agents were contacted,

¹² From 60 people identified ("participants and facilitators" agents related to technology, in principle) 23 interviews were completed and only 17 interviews were useful for the survey. The rest did not answer, claimed not to know the technology in depth or referred the survey to more expert people.

and 23 interviews were completed (see Table 3 in the Annex). The survey was conducted over a period of two months, from December 15, 2021, to February 15, 2022.

The content of the survey was adapted depending on whether the agents are directly involved in the supply chain or whether the interviewee belonged to the group of “facilitators”, that is, the providers of technological solutions or to the public sector. The classification of agents is depicted in Exhibit 2.

The study has identified 17 ongoing or completed projects that use blockchain technology to guarantee certain production conditions through the supply chain (see Table 5 in the Annex).

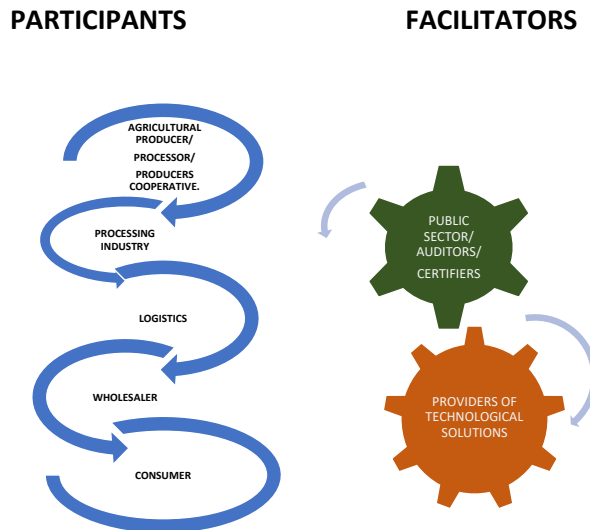


Exhibit 2. Participants and facilitators in the blockchain implementation process

4. RESULTS AND DISCUSSION.

4.1 Functionality of blockchain technology and its evaluation by the agents.

The first conclusions drawn from the surveys carried out is that, although in general there is considerable interest in this technology among professionals in the sector, those who work in connection with the transformation and distribution industry are particularly convinced of the benefits of the implementation of blockchain.

Also, all the interviewees agree that the implementation of blockchain make it necessary to improve data management across the value chain. Quotes from the interviewees state that the integration of the data in a blockchain system is expected *"to end the lack and the confusion of information"*.

In all the cases analysed, the blockchain acts as a database. Therefore, the value of the technology lies in guaranteeing the complete flow of data and information between companies throughout the entire system. The competitive advantage of blockchain over other decentralized databases is that the data cannot be manipulated and that its integration into a decentralized system provides greater transparency. The implementation of these systems has also meant, in all cases, the improvement of data collection and integration of process information, since the data must be recorded completely and adequately to generate a hash and move on to the next link in the chain.

In relation to the usefulness of the token, it is mentioned that it considerably helps the mandatory registration of transactions and the registration of additional controls that guarantee the traceability of production at a point in the chain where fraud can occur (for example, the preparation of batches or batches after the auction (case of skewered hake) / after milling (case of olive oil) / cutting (case of the meat industry)).

In relation to the evaluation of the projects, all the agents agreed on the appreciation of the virtues of blockchain previously described (immutability, transparency, or decentralized management). They also agreed that its effective implementation in the logistics chain during transport B - B (between companies) is more consolidated than along the entire supply chain P(producers)-B-B-C (producer-companies-consumer), which coincides with the conclusions drawn from the literature review (Berneis, 2021).

Most of the solutions analysed in this study have not advanced beyond the "pilot" phase, either because they are currently being tested or because they have not been consolidated. The interviewees who had participated directly in the implementation of non-consolidated projects agreed that the reasons why these are not scaled up lies in the difficulty of translating the added value of the system (traceability guarantees) into economic benefits. For this reason, some cases that that can be considered successful disappear when the financial support that facilitated their initial implementation. From the results of the interviews, it can be deduced that the main value of blockchain compared to traditional distributed databases is that it increases trust because the data that is encrypted in the blockchain is unalterable.

The interviewees agreed that for logistics control, a "normalization" of the use of blockchain technology was already taking place, making it very suitable to guarantee the control of certain parameters (temperature, origin, storage time of food products) and providing improved guarantees of the data not being manipulated, and even improving access to these records, by ensuring their availability and increasing the speed of consultation.

They also agreed that, compared to other industries, the food supply chain is perhaps one of the most complex and fragmented chains from a logistical point of view. Therefore, when blockchain is used, a greater heterogeneity of data might be encrypted with different purposes. Systems that in principle guarantee the same parameter (for example origin) are designed to host different information. Therefore, the guarantees of identity, origin, and production conditions currently offered by the blockchain systems used would only be comparable/valuable to the extent that they use the same standards for data collection and integration.

Among the Spanish projects analysed, some projects currently in the testing phase, such as SvoTan or Iberchain, could use data processing formulas that can be extrapolated to relevant production volumes so that they can be sufficiently scalable or serve as inspiration for relevant "de facto" standards, although in no existing case there are "de iure" harmonized standards.

4.2. Treatment and exploitation of data

All the agents that implemented these systems agreed that the projects introduced an improvement in the collection and traceability of the data handled by the different agents involved, by having to identify, order, document and write down data identifying the transactions. However, most of those interviewed expressed that, in a system that wants to guarantee "farm to fork" production conditions, all members of the supply chain must have access to digital platforms, otherwise part of the information is lost.

In all the cases studied, data required by legislation is included, together with other additional data. This amounts to a large quantity of data, already being reported to public administrations in Europe, and to which several of the agents referred. This information is part of the system of quality and health guarantees (Hernández San Juan, 2022) in the EU. However, as of 2022 it cannot be exploited automatically to integrate it or reuse it as part of private applications, despite being basically the same information reported to the administration (registers of phytosanitary treatments, fishing catches, transport notes, or delivery notes).

These databases also depend on and are reported to different public or private organizations in the different EU quality schemes¹³. Difficulties due to the lack of centralization and reuse of data is also a disadvantage in its use for or allowing the scalability of projects which in principle, could be extrapolated to various regions of Spain. This is the case of its application to the production of quality oil, wine, cheese, meat products derived from extensive livestock or other products that have production conditions of great organoleptic and environmental quality and that, however, cannot be differentiated in distribution or before the consumer to potentially explain price segmentation.

Regarding the reuse of the designs of the tested blockchain systems, it seems that most of the pilot projects that integrate production/batch tracking data have been designed with an individual perspective and are not scalable.

4.3. Governance

Improved governance is a potential main advantage of blockchain due to transparency, integrity of information, and collaboration ensured by a decentralized model. However, those who directly participated in the implementation of systems agreed on the difficulty of involving all the operators in the introduction of additional data and records and in the additional effort involved in maintaining the system¹⁴.

Although most of the interviewees pointed to governance (in its different facets) as a problem to be addressed, almost none of them specified solutions. For this reason, perhaps the agents describe an unequal interest in the adoption of these systems depending on their participation in the chain. In the purely logistics part and in B-to-B solutions, blockchain systems have been integrated as a way to ensure initial availability conditions and traceability of transport times and conditions and it seems that there is a certain consolidation of these solutions.

In the Producer-B-B-C solutions, the posture is more sceptical. All the agents that have participated in the projects have agreed on the benefits of blockchain for ordering and guaranteeing data (by having to enter it into the system at a certain time and not being able to alter it), but they have also agreed on the difficulty of involving all the agents in the system and in the low effective profitability in the use of technology by small producers compared to the effort and demand to feed/implement or maintain the information.

¹³ https://ec.europa.eu/info/food-farming-fisheries/food-safety-and-quality/certification/quality-labels/quality-schemes-explained_en

¹⁴ After the disappearance of the public financing line, some projects that were already in production have been abandoned since these competitive advantages did not, however, translate into lower costs for the producer, nor were there other economic advantages.

Of all the pilot projects identified, only the project where the customers were willing to pay a higher price and this price was passed on to the producers¹⁵ a real interest was expressed in keeping this system running.

In the cases studied, which are all permissioned decentralized systems, the rules defined in the consensus process and from which it is decided which transactions are valid (protocol definition) must involve all the participants and that may be the reason why In the cases studied, these systems, even if still rather complex, will work better in companies where the chain is controlled by a single agent that controls everything from production to sale.¹⁶

Implementing distributed registry technologies between multiple entities implies that all the parties that wish to carry out transactions must agree on the platform of choice and on the data formats and processes to follow. Therefore, good organizational governance of the system requires a participatory process between the small producers, with transformers and transporters, and from these into the distribution chains on how the information "of chain" is managed, organized, and stored within the chain of blocks.

After reaching the previous agreement, once the system has been implemented, chosen or configured which is going to be the oracle and the taped information, the implementation of blockchain empowers the developers (or node controllers) to be the main organ behind company decisions, which also generates doubts about its adoption.

Further, in relation to the governance of the system, the scientific experts consulted, who had participated as advisors in projects, referred to the needs for standardization. Currently there are not by right (*de iure*) standards *stricto sensu* in the field of blockchain. In the specific case of governance there are only recommendations at the ISO level regarding the automation of processes in situations with multiple participants (*ISO/TC 307/WG 5 N 102*).

4.4. Scalability.

The projects studied and analysed through interviews present two scalability problems. The first, already discussed, is derived from the lack of standards (whether *de facto* or by right) (V́ctor & Ana Isabel Ṕrez Molina, 2019) of governance and the heterogeneity of the data managed off-chain, which makes it difficult for the pilots studied to be extrapolated to similar cases.

The second problem is about the interoperability of platforms. This issue is currently being addressed with the formation of consortiums. However, the integration of information through consortiums that use the same DLT, in any case, is not complete yet, because part of the information that differentiates one product from another is lost in the process.

In the case of the integration of the information derived from the production conditions in a P-B-B-C blockchain system is particularly challenging, since the more the information reflects the specific particularity of a product and the whole system is adapted to particular situations, the more the scalability of the projects will be conditioned.

¹⁵ Galpagro, that supplied certain customers in the Netherlands who wanted to purchase from small farms

¹⁶For example, Lidl or Carrefour that promote these projects to promote or differentiate a certain product range and is therefore a condition of the supplier (COREN's free-range chicken or Lidl's virgin olive oil). If an investment in time and capital is required, it is logical that those who do not perceive a clear benefit from the implementation of the system lose interest in remaining in it.

On the contrary, the scalability of very small systems adapted to particular cases where the information generated in the cultivation process is fully owned by each of the relevant agents (producers, processors, transporters, distribution) is perfectly possible from a technical perspective. However, here the scalability issue lies on the fact that these "ad hoc" systems have not achieved yet an economic impact for these producers, because the economic size was probably not enough to create a "brand" or promotion that would make that the intermediate agent or the consumer would recognize them and pay more for the product.

In any case, from the interviews it can be deduced that most of the projects completed and implemented "successfully" have not been consolidated, much less scaled up. The motivation of the most important agents (those closest to agri-food production) to continue providing genuine information for the blockchain systems usually ends together with the public financing of the project.

Therefore, the respondents think that, in order to be able to involve large-scale distribution and marketing agents, it would be necessary to design common models for different geographical regions (for example, applicable to several appellations of origin or to differentiated quality brands in the same DLT) that would allow the development of a sort of "de facto" standard. In addition, standards and protocols should also be developed to arrange/audit the information that would allow connecting isolated DLT systems.

4.5. Costs and availability and access to public economic support.

In relation to the availability of technology, there are separate cases depending on the year of implementation of the projects. In those that were deployed in 2018 and 2019, the cost of maintaining the system was considered by respondents as a barrier to introduction, which (depending on the number of transactions stored in the blockchain) the interviewees estimated at a minimum monthly cost of around 3,000 euros/ OP (producer organization), hard to bear for small businesses¹⁷.

The projects that are being deployed from 2020, however, seems that can benefit from the Alastria consortium that provides the required technology (the nodes) without incurring in transaction costs. Therefore, once the system has been developed or implemented, costs would be limited to the maintenance of the required computer system. To this regard, In Spain, some research institutes and other agents have been identified as promoters of this change¹⁸.

¹⁷ Lack of supporting infrastructure it seems partially developed with solutions provided by Alastria or but in order to fully adopt a DLT-based platform into a business, the supporting infrastructure must be already completed by the introduction of digital identities and payment gateways and explored together with legal infrastructure and more international standards.

¹⁸ At this point it is worth making a point about the unexpected results of this research, such as the fact that, despite the fact that the bibliographic search yielded an insignificant number of scientific papers in our country, the contribution of Spanish innovation agents to employment effectiveness of blockchain technology in Europe is quite significant, our country has a significant number of research agents of recognized prestige, in particular the promotion of research institutes such as the CSIC and certain universities, the Polytechnic University of Córdoba, Seville, the of Madrid, the technological centre of Asturias. Relevant experts at the ITU level such as David Arroyo or Ismael Arribas Convenor of group 3 on Smart Contracts and their applications in ISO TC 307 and liaison officer between CEN CENELEC JTC19 and ETSI ISG PDL, In Spain there is an important blockchain consortium, perhaps probably the largest in terms of infrastructure and relevant partners in the world, which is Alastria, although less active than other consortiums such as. In addition, Connectivity Plan in the framework of Next Generation EU (NGEU) Resilience and Recovery Mechanisms plans to invest more than 2,3 billion euros until 2025 for extending broad band internet coverage and infrastructures for industry 4.0 to promote interconnectivity.

Under the heading of recovery funds, national plans are grouped together in accordance with European guidelines for financing the process of digital transformation in Spain¹⁹ The remarkable public support (Consejo Economico y Social, 2017) has made it possible for all these projects to be developed. All the projects identified, without exception, had received public funding, and at this time there are many opportunities for agricultural SMEs in terms of access to aid for technological modernization, which is facilitated and offered by the surveyed consulting firms themselves.

Still, and despite the above, respondents consider that the costs linked to the complexity of starting up and maintaining the blockchain system are a barrier to the deployments.

In all the projects aimed at certifying high-value foods due to their production conditions, all the agents of the primary sector and producer organizations stated that the implementation of information management systems that used blockchain had improved transparency, organization and guarantees of the information associated with these foods. However, the additional effort required and the cost of maintaining the system was not compensated by an increased price for the final product. Therefore, the end of public financing, expected in most of existing deployments, will become a cause for the abandonment of projects.

In relation to access to existing public funding, all the projects identified, without any exception, had received some type of public support, signalling that there are many opportunities for agricultural SMEs in terms of access to aid for technological modernization, which in many cases is facilitated and offered by the surveyed consulting firms themselves.

5. CONCLUSIONS/CRITICAL DISCUSSION:

The first of the research questions in the paper was related to the interest and the conditions found in Spain for the adoption of blockchain technologies in the agri-food field and the identification of relevant cases of implementation. Through the survey and desk research, 17 projects have been identified that use blockchain technology to certify aspects related to production conditions, which shows that, despite the low impact of these projects so far in the scientific literature, there is a significant number of experiences in Spain.

However, from the available evidence, it can be shown that the implementation of blockchain technology in the agri-food industry is complex, and that the cost and effort are only worthwhile and become consolidated when both there is a need to secure the information and the results provide some commercial competitive advantage. For this reason, there is an increasing use of this technology in the logistics part of the value chain for the control of certain parameters (for example, in the product entry in containers²⁰ and the international transport conditions), using parameters that are easily identifiable and exchanged across the value chain. However, the projects to certify quality parameters linked to the production conditions that involve all the agents and cover the whole value chain (from the producer to the consumer) have not been consolidated so far.

19 <https://planderecuperacion.gob.es/> SME Digitalisation Plan (public investment of close 5 billion until 2030 (beneficiaries SME), National Digital Skill Plan (3,75 billion euros (period 2021-2023), Connectivity Plan (more than 2,3 billion euros until 2025), public administration digitalisation plan (2,6 billions of euros over the next three years) national Artificial Intelligence Strategy (600 million euros in the period 2021-2023). Together these initiatives foreseen 16,25 billion in public investment, which 25,4 euros billions will be financed by European funds from the NGEU Resilience and Recovery Mechanisms.

²⁰ Blockchain en el transporte marítimo: caso de éxito | Revista Ingeniería Naval <https://sectormaritimo.es/blockchain-transporte-maritimo-caso-exito>.

At the same time, the low percentage of companies that responded adequately to the survey compared to the number of projects identified (12%)²¹ may display the fact that in many cases these companies are operating with little knowledge of the technology. It even seems that in some cases the choice about the use of this technology derives from its popularity and not because of its advantages. Respondents included comments such as "it was fashionable" or has been, in part, "sold by the consultants".

Regarding the challenges of implementing the blockchain technology in the agri-food industry, the first is related to the management or organization of the data that is necessary to guarantee the conditions of production and, in particular, the treatment of the raw data prior to its encryption on blockchain. If the data collection is not correct, the whole system will be flawed. Secondly, there is the issue of the usage of homogeneous data sources to allow for the scalability of projects.

In relation to the data and information stored in the system, it should be noted that a good part of the information that is being integrated and provided to the system is also provided to the official records. In this regard, the Public Agricultural Administrations in Europe already enjoy a large amount of information, provided by the farmers and ranchers themselves, and by the companies supplying goods and equipment to the agricultural sector, in accordance with national and EU regulations. These include data on plant and animal health, the hygiene of primary food production, agricultural by-products and waste, or even financial information on public subsidies. Having to provide the same information several times through different formats, channels and to different organizations, together with the lack of centralization and reuse in general of this data or information is currently an inconvenience in the adoption of any improved information management system (including blockchain) due to the additional bureaucracy involved. However, the existence of this information and its possible availability could become an opportunity for the implementation of blockchain if a homogeneous and automatic exploitation of data were possible, not only in Spain but also within Europe. Also on this same topic, with the objectives of avoiding data manipulation and excessive bureaucracy, research is also being done on automatic data collection through sensors (Arroyo-Guardeño David, Diaz-Vico, Jesús, Hernandez Encinas, Luis., 2019).

Another important point is the absence of relevant regulations or standards related to the implementation of blockchain technology, an aspect that goes beyond the agri-food sector. It is also unclear its full compatibility with other regulations such as the European Data Protection Regulation.

The experts who responded in detail to the more technical questions in the survey also spoke about the need to finish developing the technology, in particular referring to aspects such as interoperability and security.

In relation to the challenges presented by the governance of the system, it should be noted that blockchain integrates authentication in the document itself (data relied on as the basis, proof, or support of the product) itself and, in all the cases studied, permissioned systems are being used. In fact, there is currently a proliferation of permitted DLT systems that can condition the virtues of the technology both because of the fragmentation they can induce, and because of its

²¹ Only two of the producer's company managers who were interviewed explained in some detail the functionalities of the new technology.

difficult relationship with governance²², In this sense, a good governance system implies involving all the relevant actors and reaching a consensus on the conditions, participation, entry, permissions, information provided, oracles and the algorithms used.

The minimum set for blockchain governance would require that all parties who want to transact must agree on the platform of choice and on data formats and processes to be followed. This may be challenging due to the lack of trust between parties (who may otherwise be competitors), the possibility of disintermediation in the value chain, the lack of interest to join and the required investment in time and capital. Depending on the case, the risks can be too daunting to adopt DLT.

Further, adopting a DLT is already complex enough for a single organization that is managed centrally. But it becomes more complex when introducing DLT to a multi-entity environment that is not centrally managed, e.g., a wholesale supply chain. Up to date, blockchain-like platforms are better suited to B2B models or for internal usage within a single organization. In practice we can see that Blockchain-like systems are mostly adopted in the corporate sector where there is a need for controlled governance and there are restrictions over shared data. For example, an organization can build a blockchain-like system where the transaction details are only shared with the concerned parties in a specified pattern. When setting up a blockchain system between different organizations in a multi-entity DLTs, the coordination issue can be partially solved with the formation of consortiums. For instance, in Spain there is the Alastria consortium, which is one of the largest of the world. There are also other consortiums in Europe (Adan) or in South America (b-Connect)²² that are becoming increasingly active.

About the public support to make the technology available to the private sector, Spanish administrations at different levels are already using EU funds for the incorporation of digital technologies in the agricultural sector (especially in the production sector). This has resulted in some relevant projects already integrated into producer organizations with sufficient volume and, therefore, with both some bargaining power²³ with the public administrations and a commitment to modernization, including conscientious and well-trained employees that surveys have highlighted as a main factor for the adoption of these technologies. The constrain is consequently, there yet be a sufficient culture of digital transformation, the application and a shortage of projects in the digital skill training (Palomo-Zurdo & Dopacio Cristina Isabel, 2022). The limited scope of the fundable projects and a lack strategic vision for joint change that unites the digital transformation projects of companies together with the possibilities of administration and training strategic vision for joint change grouping the digital transformation projects of companies together with the possibilities of administration and training which can risk losing a great opportunity to develop technologies that can really boost the economy.

The public support in Spain happens mostly in the experimental phase. However, for the consolidation of solutions this is clearly not enough, as their consolidation would require a transition path that incorporates other measures beyond pilot projects financing: technological, administrative and legal developments, and training in this technology. In particular, the update of the legal and administrative framework would allow official information already being collected, such as certificates of origin and health, bills of landing and other data derived from official controls and documents, to be reused in the blockchain system. This would be the only

²² Nevertheless, in any case, the IBM or Alastria system based on Hyperledger fabric was used in the projects studied. or in Quorum, both systems being interoperable with each other.

²³ Covap, Cofradía de Celeiro, Galpagro

way in which the blockchain would provide a real utility by not generating an "added bureaucracy", but rather helping to simplify the bureaucratic processes related to the registration of animal and plant identifiers, exchanging data records related to sanitary and animal and plant management and production.

It would therefore be interesting to direct future research towards aspects that allow, on the one hand, to address the shortcomings in terms of the exploitation of data that could offer some competitive advantage and, on the other hand, on how to improve the exploitation and reuse of data that are currently reported to public administrations.

In terms of final conclusions, it should be noted that the number of cases studied, and their current status (mostly in the testing phase) do not provide enough evidence to draw definitive conclusions, although they are enough to extract some insights (above) and propose new lines of work such as those listed below.

The first conclusion consists of the interest in promoting the development of policies and guidelines on the integration of new digital technologies in animal and plant traceability systems. For example, the incorporation of data in an automated manner or its evaluation by means of artificial intelligence systems, a field in which experimentation is currently being carried out and which should be accompanied by observation and monitoring for the promotion of homogeneous policies at the community level. Likewise, for the efficient delivery of products from farms to consumers. Several research projects that analyse the integration of agricultural production data are in the pilot phase, the assessment of their results and its potential usage in blockchain systems could mean an important turning point in the implementation of the technology.

A second conclusion is the need for proper guidance in the selection and integration of control data in projects. For example, the distributed ledger itself may be relatively inexpensive, while collecting the data necessary to make the ledger useful, such as collecting animal DNA or other data that would allow traceability and auditability of the system, could be expensive. Likewise, the scalability of current pilot projects in certain cases (appellations of origin) depends on this selection of data, which could also provide the advantage of contributing to the creation of "de facto" standards.

There are other conclusions of interest that have emerged as a result of the study, such as the relevant role and need for modernization of the evaluation and exploitation system of the official public control registers in the EU, as well as the automated incorporation of data. Similarly, the absence of standards on the construction of the consensus test, or the lack of automation in the introduction of information may hinder the quality of the archived information and therefore the guarantees provided by this technology. It might even turn out that the overall reliability is less than that provided by other systems, such as artificial intelligence systems, constraining severely its prospects.

Also, from this study it could be concluded that a considerable part of the future success in the implementation of this technology depends on its ability to connect to existing databases, both public and private, that is, registry systems and European official controls, and industrial production and marketing systems related to resource planning, warehouse management and manufacturing. For this reason, and due to the proliferation of infrastructures to facilitate the use blockchain, the development of middleware and communication protocols that can unite existing systems constitutes an important research and development niche for the effective deployment of this technology.

Last but not least, the research conducted points to the need for awareness and adequate training in the implementation of blockchain technology in the agri-food industry.

ANNEX 1 - QUESTIONNAIRES

Fecha de entrevista : _____

Nombre del entrevistado: _____

Nombre de la compañía: _____

Departamento: _____

Posición: _____

Años de experiencia: _____

PARTE A: INTRODUCCIÓN

Introducción: Gracias por su tiempo para contribuir a esta investigación. Explicaré brevemente mi papel, el objetivo de este estudio de investigación y cómo se llevará a cabo la entrevista.

El propósito de la investigación es analizar el grado de conocimiento en España sobre la tecnología blockchain aplicada a la cadena agroalimentaria y la percepción que existe su posible utilidad.

Además, queremos conocer las ventajas o desventajas que se observan por parte de los actores que han participado de experiencias de uso de sistemas basados en blockchain y las ventajas /oportunidades y dificultades/desafíos que han observado en relación con la implantación de la tecnología.

Asimismo, en la utilización de la tecnología de la cadena de bloques a su caso concreto nos interesa conocer que "prueba de concepto" se utiliza para perfeccionar el algoritmo y qué intereses satisface de las que están involucradas en la cadena.

Confidencialidad: La información obtenida de esta entrevista es confidencial. Los datos adquiridos serán utilizados de manera agregada y con el único objetivo de documentar este estudio y no se transmitirán a terceros. El nombre de su empresa, su nombre y cualquier otro será tratado de manera confidencial y se codificará la información que lo identifique a usted o a su empresa.

Puede contactarme a través del siguiente número de teléfono: 615918263

La parte B y C contienen las preguntas concretas planteadas a los distintos grupos de agentes.

PARTE B: GUÍA DE ENTREVISTA PARA EMPRESAS QUE PODRÍAN ESTAR INTERESADAS O ESTÁN YA UTILIZANDO TECNOLOGÍA BLOCKCHAIN.

Preguntas generales

1. ¿Puede describir brevemente su puesto dentro de su empresa?
2. ¿Cuál es el negocio principal de su empresa?
3. ¿Puede describir brevemente el papel de su empresa dentro de la cadena de suministro agroalimentario? ¿dentro de la cadena en qué tipo de actividades están involucrados?
4. ¿Qué actividades / procesos necesitan de una tecnología de encriptado/seguridad de los datos? ¿cuáles son los aspectos más y menos importantes en el proceso de valor de los productos con los que trabajan?

Forma actual de trabajar

5. ¿En qué parte del proceso se identifican la mayoría de los problemas / desafíos?

6. ¿Qué tipo de problemas se perciben en este momento para la cadena de suministro agroalimentario? (Gran cantidad de documentación, ineficacia, colaboración, retrasos, problemas de comunicación, datos / TI, ¿otros?)
7. ¿Qué tipo de problemas se ven mejorados con el empleo de la tecnología blockchain?
¿Consecuencias?
8. ¿Qué actividades pueden y deben mejorarse?, ¿cómo se pueden mejorar?
9. ¿Qué tipo de mejoras en relación con la comunicación/documentación o digitalización de la cadena de suministro agroalimentario se han realizado en los últimos años? ¿Fueron exitosas?
¿Por qué y por qué no?

Preguntas de seguimiento relacionadas con la documentación

10. ¿Qué tipo de documentación se necesita / se prepara para los envíos?
11. ¿Cómo se percibe el proceso de documentación en su organización?
12. ¿Cuánto tiempo se dedica a verificar / preparar documentos? ¿Es posible estimar esto en costos?
13. ¿En qué medida cree que la forma actual de trabajar en materia de documentación es suficiente para el futuro? (Para seguir siendo competitivo / exitoso)

Preguntas de seguimiento relacionadas con la comunicación

14. ¿Cómo percibe la cantidad de comunicación necesaria con otros actores de la cadena de suministro agroalimentario?
15. ¿Cómo percibe la colaboración a lo largo de la cadena para realizar/recibir pedidos con éxito?
16. Preguntas relativas a la incorporación de Tecnologías de la Información a la cadena de suministro agroalimentario.
17. ¿Cómo describiría el panorama actual de las tecnologías de la información? ¿Es suficiente?
18. ¿En qué medida las tecnologías de la información que están utilizando son suficientes para permitir un seguimiento o recabar la información de los procesos realizados? (Datos disponibles, interfaces con otros sistemas, etc.)
19. ¿Qué opina sobre la digitalización comercial de la cadena de suministro agroalimentario?
20. ¿Hasta qué punto es necesaria la digitalización del comercio?
21. ¿Qué le gustaría lograr en los proyectos de digitalización? ¿Qué aprendió de los proyectos de digitalización ejecutados en el pasado?

Preguntas de seguimiento relacionadas con la estandarización

22. ¿Conoce algún proceso de estandarización en su ámbito? ¿participa del mismo?
23. ¿Forma parte de iniciativas internacionales para mejorar la logística?
24. ¿Ha adoptado algún tipo de estándar o procedimiento de uso común? ¿en qué ámbito: nacional/europeo/internacional?

25. ¿Cuál es la fuente de su conocimiento tecnológico aplicado a estandarización? ¿Cómo se mantiene al día?

Conocimiento e interés sobre la tecnología blockchain.

26. ¿Qué sabe sobre la nueva tecnología blockchain? (¿Qué tipo de aplicaciones de blockchain conoce? (Instituciones financieras, bitcoin, etc.) ¿Cuándo surgió por primera vez su interés en blockchain?

27. ¿Ha cambiado su interés en blockchain con el tiempo?

28. ¿Qué tipo de oportunidades le ofrecen las soluciones basadas en blockchain? ¿Cuáles considera que son las características más importantes / interesantes que ofrece la tecnología blockchain? (Descentralizado, inmutabilidad, consenso, transparencia, contratos inteligentes, escalabilidad, etc.) frente a otras tecnologías? Específicamente para su empresa, ¿de qué manera la tecnología blockchain sería beneficiosa / no beneficiosa?

29. ¿participa en un proyecto donde implementar blockchain? ¿Está involucrado en el proceso de implementación? ¿Cómo promotor/colaborador? ¿se trata de un proyecto internacional /nacional/local?

¿Ve posibles limitaciones para la tecnología en su cadena de suministro agroalimentario?

30. ¿Por qué te interesa implementar blockchain en tu empresa?

31. ¿Cómo le gustaría implementar blockchain en tu empresa?

32. ¿Cuáles han sido sus experiencias con empresas que ofrecen soluciones blockchain?

33. ¿Cómo son sus relaciones con sus socios de la cadena de suministro agroalimentario?

34. En la literatura, muchos investigadores afirman que las empresas en una colaboración a menudo enfrentan con problemas en relación con el intercambio de información y la falta de confianza.

- ¿Cuáles son sus experiencias con estos desafíos?
- ¿Tiene algún problema con el intercambio de información?
- ¿Tiene problemas de confianza?
- ¿Ve alguna posibilidad de cómo blockchain podría afrontar estos problemas de colaboración?
- ¿En qué medida espera que blockchain resuelva los problemas mencionados anteriormente u otros? ¿qué problemas?

35. Si pudiera desarrollar una plataforma blockchain conforme a sus necesidades, ¿qué requisito consideraría importante incluir?

36. ¿Qué cree que cambiará en su negocio al adoptar una tecnología tan nueva como

37. blockchain?

- ¿Hasta qué punto cree que su empresa está preparada para adoptar una nueva tecnología como blockchain?
¿En qué período de tiempo?
- ¿Qué barreras debe superar su empresa para estar preparada?
- ¿Qué aspectos considera motivadores para adoptar blockchain?

- ¿Por qué no implementaría la tecnología blockchain en su organización y por qué?
38. ¿Alternativas para la tecnología blockchain? ¿Hasta qué punto su empresa siente la necesidad de involucrarse en proyectos de digitalización / blockchain para permanecer competitivo en el futuro?
 39. ¿En qué condiciones o bajo qué supuestos participaría su empresa en una gran plataforma blockchain?
 40. ¿Qué vías de apoyo o de financiación conoce para la transformación tecnológica de su empresa? ¿se han financiado inversiones o experiencias de implementación de tecnología blockchain con cargo a los fondos europeos?
 41. ¿Qué otro agente me recomendaría que contactara al objeto de conocer mayores detalles del impacto o la utilidad del blockchain en las cadenas de suministro en España?

PARTE C: GUÍA DE ENTREVISTA PARA AGENTES DEL SECTOR PÚBLICO/ACADEMIA.

- 1) ¿Conoce la tecnología blockchain? ¿sus usos? ¿y sus posibles aplicaciones a la cadena de suministro agroalimentario?
 - 2) ¿conoce experiencias o personas en su entorno que estén utilizando esta tecnología?
 - 3) ¿Cuándo surgió por primera vez su interés en blockchain?
 - 4) ¿ha trabajado/impulsado/analizado/participado directamente en algún proyecto o estudio que utilice la tecnología blockchain? ¿podría describir brevemente en qué consistía?
- 2.1) ¿qué utilidad concreta prestaba esta tecnología?
 - 2.2) ¿ha intervenido /supervisado algún proyecto que utilice esta tecnología?
 - 3) ¿Con qué tipo de proyectos/expedientes trabaja? (sector/ industrias /ámbito académico etc.)
 - 4) ¿Qué experiencia puede transmitir sobre opiniones de terceros en relación con el uso de blockchain?
 - 4.1) ¿en su entorno, puede decir que ha cambiado el interés por el uso del blockchain con el tiempo?

Soluciones blockchain en cadenas de suministro agroalimentario.

- 1) ¿Conoce la utilidad la tecnología blockchain en la cadena de suministro agroalimentario?
- 2) ¿Qué conocimiento tiene con las aplicaciones blockchain en las cadenas de suministro agroalimentario? ¿nacionales/internacionales? ¿sectores? ¿utilidad? ¿ámbito académico/industrial/experimental?
- 3) ¿Qué tipo de oportunidades señalaría en relación con las soluciones blockchain en las cadenas de suministro agroalimentario?
- 4) ¿Cuáles son las limitaciones de esta tecnología en las cadenas de suministro agroalimentario?
- 5) ¿en su opinión, qué industrias específicas que podrían estar especialmente interesadas en la tecnología?

6) ¿conoce/existe/ha utilizado algún sistema de financiación con cargo a fondos europeos para apoyar el proceso transformador de las empresas?

Razones para implementar la tecnología blockchain

1) ¿sus administrados/ alumnos/ investigadores ya tienen una idea de cómo implementar la tecnología blockchain?

1.1) ¿Conocen áreas problemáticas específicas que la tecnología podría resolver?

1.2) ¿A la hora de lanzar un proyecto, necesita identificar primero la utilidad que esta tecnología podría tener para el mismo?

2) En la literatura, muchos investigadores afirman que entre las relaciones empresariales que se producen en la cadena de suministro y distribución alimentaria a menudo surgen problemas en el intercambio de información y también problemas de confianza. (por ejemplo, en materia sanitaria/origen/garantía de pago/falsificación de producto) ¿cree que en España existen esos problemas?

2.1) ¿Cuáles son sus experiencias con estos desafíos? ¿nacionales/internacionales?

2.2) ¿Ve otros problemas en las cadenas de suministro agroalimentario que podrían resolverse? ¿a través de blockchain?

3) ¿Ve posibilidades del uso de blockchain para resolver problemas de confianza?

4) ¿Cuándo evalúa o analiza una experiencia o proyecto concreto en el que introduce la tecnología blockchain en España diría que existe un impacto en la relación entre los socios de la cadena de suministro agroalimentario durante y después de la implementación?

5) ¿Qué otros agentes me recomendarían que contactara al objeto de conocer mayores detalles de la utilidad del blockchain en las cadenas de suministro agroalimentario en España?

ANNEX II

Main regulatory control, monitoring provisions that require the registration and exploitation of data derived from agri-food production in Spain.

Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety.

Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001 on general product safety.

Ley 17/2011, de 17 de Julio, on food safety and nutrition.

Real Decreto 1808/1991, de 13 de diciembre, that regulates the mentions or marks that allow to identify the batch to which a food product belongs (BOE 25.12.1991).

Real Decreto 2207/95, de 28 de diciembre, on hygiene of food products (B.O.E 27.02.1996), result of the transposition of the Directive 93/43/CEE.

Real Decreto 479/2004, de 26 de marzo which establishes and regulates the General Registry of Livestock Farms.

Real Decreto 728/2007, de 13 de junio by which it is established and regulates the General Registry of Livestock Movements and the Registry general identification of individual animals.

Real Decreto 1614/2008, de 3 de octubre, relating to the animal health requirements of animals and aquaculture products, as well as the prevention and control of certain diseases of aquatic animals.

Electronic Record of Transactions and Operations with Phytosanitary Products (RETO) established the Real Decreto 285/2021, de 20 de abril.

Real Decreto 1311/2012, de 14 de septiembre which establishes the framework for action to achieve a sustainable use of plant protection products.

PROLAC database. Real Decreto 95/2019, de 1 de marzo, which establishes the contracting conditions in the dairy sector and regulates the recognition of producer organizations and interprofessional organizations in the sector,

ARCA system regulated in the Real Decreto 45/2019, de 8 de febrero which establishes the zootechnical standards applicable to purebred breeding animals, hybrid breeding pigs and their reproductive material, updating the National Program for the conservation, improvement and promotion of livestock breeds.

Computer system for registering animal feed establishments. Real Decreto 629/2019, de 31 de octubre.

ECOGAN system created by the Royal Decree that regulates the general registry of best available techniques in farms and the support for the calculation, monitoring, and notification of emissions in livestock.

The National Registry of Producer Organizations and Associations of Producer Organizations regulated in the Real Decreto 532/2017, de 26 de mayo.

The State Register of organizations and associations of organizations of producers of raw tobacco referred to in the Real Decreto 969/2014, de 21 de noviembre, which regulates the recognition of producer organizations, the extension of standards, contractual relations and the communication of information in the raw tobacco sector.

The National Register of organizations and associations of organizations of milk producers regulated in the Real Decreto 95/2019, de 1 de marzo.

The National Registry of organizations and associations of producer organizations provided for in el Real Decreto 541/2016, de 25 de noviembre, which regulates the recognition of producer organizations and their associations in the rabbit sector.

Wine Sector Market Information System del Real Decreto 739/2015, de 31 de julio.

Unified information system of the dairy sector regulated in the Real Decreto 319/2015, de 24 de abril, on mandatory declarations to be made by first buyers and producers of milk and dairy products from cows, sheep and goats.

REGMAQ System: Real Decreto 448/2020, de 10 de marzo, on characterization and registration of agricultural machinery.

Information system of the olive markets regulated in the Real Decreto 861/2018, de 13 de julio, establishing the basic regulations on mandatory declarations in the olive oil and table olives sectors.

El Real Decreto 1054/2021, de 30 de noviembre which establishes and regulates the Register of professional plant operators, the measures to be complied with by professional operators authorized to issue phytosanitary passports and the obligations of professional operators of reproductive plant material and modifies various royal decrees in matters of farming.

Other data sources:

The data of the application for CAP aid established in the Real Decreto 1075/2014, de 19 de diciembre.

The data related to payments of the European agricultural funds, FEAGA and FEADER, compiled based on the provisions of the Real Decreto 92/2018, de 2 de marzo.

Sistema TRACES (*TRAdE Control and Expert System*) is a web-based veterinarian certification tool used by the European Union for controlling the import and export of live animals and animal products within and without its borders. Its network.

ANNEX III – Summary Tables

Table 1: Companies that provide software for the traceability of fishery products that use blockchain technology.

Companies that provide software for the traceability of fishery products that use blockchain technology		
<u>Pacific FishTrax</u>	traceable canned tuna	USA
<u>Golfo Salvaje</u>	traceable canned tuna	Mexico
<u>John West Australia</u>	traceable canned tuna	Australia
<u>Peces legítimos</u>	" smart digital identity (Mowi)	USA
<u>OpenSC</u>	low carbon food	Australia
<u>fishworldtrack</u>	origin of the seafood fish	SPAIN

Table 2: Blockchain lobbies in Spain from database: “transparency register EU”.

ORGANIZATION	ACTIVITY	INDUSTRY	REFERENCE	Blockchain application example
FOODRATION4ALL S.L.	Food NGO	FOOD BANKS	https://foodration4all.com/	Purse card to obtain food/reduce food waste
MEDIAPRO Group	Technical services supplier to the audio-visual sector.	AUDIOVISUAL	AUDIO-VISUAL MEDIAPRO leader of the European Audio-visual	Market Copyright
STARUP VILLAGE	Support for entrepreneurship for the development of rural areas	RURAL DEVELOPMENT	http://startupvillage.eu/	Support for tourism activities, rural geolocation
UNESPA	Insurance	INSURERS	http://www.unespa.es	Smart contract applied to the management of insurance procedures.
FUNDACION CTIC CENTRO TECNOLOGICO DE LA INFORMACION Y LAS COMUNICACIONES EN ASTURIAS (CTIC)	Research and development of technological solutions in various fields	MULTIPLE PROJECTS IN MANY AREAS OF ACTIVITY (Several projects based on TELOS are identified)	Telos blockchain	Several, among others: a query application for the final consumer of the product, who wants to know more information about its origin and other characteristics
Health Identification Card	Technological applications health sector	IT APPLIED TO THE HEALTH FIELD	http://www.fundacionctic.org	Health Code
AEI CIBERSEGURIDAD	Business group computer security services	CIBERSEGURIDAD	https://www.aeciberseguridad.es/	“Cybersecurity Seal”, a collaborative project of a group of partners to provide a robust cybersecurity certification
COLEGIO DE REGISTRADORES DE ESPAÑA (CORPME)	FE PUBLICA REGISTRAL	PUBLIC REGISTRY	Registradores de España	Notarization of documents and authenticity.

Table 3. Agent’s map

Source	Industry	Company /Agent
Blockchain in distribution industry		
TGA	enablers/drivers. Large retailers	FM (interviewed)
JG	Large retailers	Carrefour
TGA	Large retailers	Mercadona
TGA	enablers/drivers. Large retailers	JJ (interviewed)
Magazine	Large retailers	LIDL
Blockchain in the primary agricultural and fishing sector		
TGA	Olive oil producers	Oleoestepa
TGA	Fruit and Vegetable Sector	Unica (NA)
TGA	Olive oil producers	Coexpal
JA	Fruit and Vegetable Sector	
TGA	Fruit and Vegetable Sector	Federación empresarial de agroalimentación de la Comunidad Valenciana
Magazine	Meat sector	Covap (proyecto iberchain)
Magazine	Fruit and Vegetable Sector	Cooperativa frutas y hortalizas Huelva
JE	Olive oil producers	Almazara de la Subbética (interviewed)
JG	Fisheries	Puerto de Celeiro (interviewed) EML
JE	Olive oil producers	Galpagro (MAM)
TGA	Citrus	Inmaculada Sanfeliu
Magazine	Meat sector	COREN
JG	Fisheries	Nueva Pescanova
JE	Olive oil producers	Rurápolis
Consulting digital services agri-food sector (Blockchain)		
TGA	Thoffod (Entrevista)	OGA (interviewed)
TGA	Iniciativa ecoagra	
LinkedIn	DM	IBM (interviewed)
LinkedIn	Fish World Track (pesca)	JIA (interviewed)
JE	Rurápolis	MAM (interviewed)
MLM	Hispattec	
MLM	Certificadora Comité Andaluz de Agricultura Ecológica	
JE	Wealize digital	MAC (interviewed)
JE	Overtrace	MAM (interviewed)
LinkedIn	IBM	GSC
LinkedIn	IBM Blockchain Transparent Supply,	DM
JE	IBM	LC (interviewed)
DA	KUNFUD®	IA (interviewed)
JE	Galpagro	JMC (interviewed)
UNIVERSITIES/RESEARCH CENTERS		

JE	Universidad de Córdoba	JDB (interviewed)
LinkedIn	Universidad Politécnica de Sevilla	MLM (interviewed)
LinkedIn	Universidad Politécnica de Madrid	AM (interviewed)
Agenda	Universidad Politécnica de Madrid	
JE	Universidad de Granada	FLB (interviewed)
JE	Universidad de Córdoba	JE (interviewed)
JE	Universidad de Granada	FLB (interviewed)
JE	Universidad de Córdoba	JE (interviewed)
MITECO	CSIC	DE (interviewed)
WEB	CTIC (Asturias)	
WEB	Universidad de Salamanca	
PUBLIC SECTOR (national level)		
Agenda	MITECO	PGP (interviewed)
Agenda	MAPA	CG (interviewed)

Table 4. International projects of interest.

	PROJECT	REFERENCE	OPERATION	DEVELOPER
<p>end-to-end transparency. Real-time visibility of the members of the value chain and the controls to which they are subjected (distributors, auditors, regulators) Maintenance and immutability of information / transparency, recovery and aggregation and data analytics.</p>	Best 360	https://360seafood.com/en/	printed traceability code which embeds the relevant data that allows the tracking of a product to its underlying 28rg and the relevant data sets about its origin (primary data of fisheries and farms).	
	Turkey: Cargill's Blockchain	Cargill (ref)	119 / 5.000 Combined with radiofrequency on the farm to identify the animal + control points in the distribution slaughterhouse	IBM
	Aceite de oliva Extra virge "terra Delyssa"	Wolfon 2020 (ref)	8 checkpoints. Plot, mill, facilities and distribution	IBM
	Quality line de auvenia	Carrefour (ref)	Information on the place of origin and fed, treatments, place of slaughter and distribution.	IBM
	Empresa Sea Quest Fiji Ltd & WWF	https://www.wwf.org.nz/what_we_do/marine/blockchain_tuna_project/	Combined with RADIO FREQUENCY CAPTURE zone	ConsenSys
	Mousline Nestlé+ CARREFOUR	Wyers, 219	Cultivation places, dates, quality control of potatoes (ingredients of potato puree)	IBM
	sales platform	https://www.karyonfood.com/	Origin and place of transformation	

Table 5: Ongoing or completed projects that use blockchain technology to guarantee certain production conditions through the supply chain.

(Projects identified through the bibliography and references cited by the agents)

Promoter company	Project	Industry	Utility	Degree of implementation	It has been possible to compare the information with the promoter of the project	Developer	Web information
Nutrasign	(Various) raspberry traceability	Fruit and Vegetable	Secure digital regulatory process	Pilot	NO	Food track	Nutrasign
Fish world track	Fish world track	Fisheries	Track fish from sea to table	In production	SI	Meta	https://fishworldtrack.com/CARRERODOR
Puerto de Celeiro	Merluza de pincho	Fisheries	Origin, fishing conditions, and lot traceability after auction	implemented but abandoned after end of financing.	SI	Food Trust (IBM)	LANZA EL PRIMER BLOCKCHAIN DE PESCADO FRESCO https://www.inteempresas.net/Industria-Carnica/Articulos
Navidul	Navidul	Meat	Storage and record management	Pilot	NO	Food Trust (IBM)	https://www.inteempresas.net/Industria-Carnica/Articulos
ITCL Technologic centre	Agraria	Fruit and Vegetable	Apply artificial intelligence to the entire value chain	Conceptualización	SI	Alastria	https://itcl.es/en/itcl-about-us/
Covap	Iberchain	Meat	certify Iberian meat improve the traceability of 100% Iberian pork	Pilot	NO	Alastria	https://static.covap.es/notas-prensa/2021/NP-EL-IBERICO-100-ENTRA-EN-EL-BLOCKCHAIN.pdf
Oleoestepa		Olive oil	Origin, production plots, delivery time and batches.	Pilot	YES	Alastria	https://www.oleoestepa.com/aceite-de-oliva-de-calidad/produccion-sostenible/
Inmaculada San Feliu	Traceability of citrus	Fruit and Vegetable	Origin.	No information (beginning in 2019)	NO		
Unica	Traceability of citrus	Fruit and Vegetable	Traceability for export.	No information (beginning in 2019)	NO	Sistema Informático de Trazabilidad Citrícola (SITC)	https://www.agritotal.com/nota/40637-citricos-el-sitc-ahora-incorpora-la-tecnologia-blockchain/
CTIC	DOPCHAIN	Various PDO (protected designation of origin)	Authenticity	In project	NO	Solution Dopchain (based in Ethereum) (CTIC IA AN Alastria member)	https://www.fundacionctic.org/es/proyectos/dopchain-solucion-basada-en-tecnologias-blockchain-para-la-trazabilidad-de-productos-de-origen/
Universidad de Córdoba y Fedacova.	carne de ternera	Meat	certify production conditions Farm to fork	In project	NO		https://www.iof2020.eu/trials/meat-iot-and-blockchain-for-beef-supply-chain
Fundación Patrimonio Comunal Olivarero	SAR	Olive oil	Olive oil Traceability of Olive Oil Self-control (SAR) Warehouse control.	No information (beginning in 2019)	NO		https://www.patrimoniolivarero.com/
Grupo Operativo Sostvan-Grupo Operativo E	Cows	Meat	Technological strategies to improve the sustainability of the suckler cow	In project University of León	NO	Universidad de León, Hyperledger . Linux	Home - SOSTVAN
Iberchain (PDO)	Iberico	Meat	Native Iberian breed Iberico pig. Avoid fraud	The system bases quality criteria on NIRS analyses applied to racial discrimination. (Start of the project 2019) no Alastria https://iberchain.es/	NO	Alastria	https://iberchain.es/
Control of traceability from birth to slaughterhouse as an anti-fraud mechanism for documentary suckling lamb	Lechazo CLM (PDO)	Meat	Avoid fraud. Control of traceability from birth to slaughterhouse as an anti-fraud mechanism for documentary suckling lamb CLM Cárnico	In project (starts to work in June 2022)	YES	SMEs led by KUNFUD on Alastria's T-net (Quorum-base) and EBSI (European Blockchain Services Infrastructure)	Kunfud – Private Trademark – Security Mercantile & Commercial Tort
VinAssure	Wine	Wine sector	Trace the wines from the vineyard to the final consumer.	In project (starts to work in June 2022)	NO	eProvenance company develops a platform to record data on the supply of wine in the IBM Blockchain.	https://www.eprovenance.com/home/services/vinassure/
Innovation in ornamental plant ornamental plant	planta ornamental	Fruit and Vegetable	Traceability of the distributed plants from their production, until they reach the final customer. Productivity/Process Improvement / Added Value Increase	No information (beginning in 2019)	NO		

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