Adopting Blockchain in Supply Chain – a methodological proposal to conduct a pilot

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Abstract. The world nowadays and business processes, in particular, are changing towards digitalization and reduction of time-consuming processes. Provenance and safety of products are becoming key factors for customers' trust, so traceability solutions are arising. One of the most up-and-coming disruptive technologies today is a Blockchain (BC). This paper aims to assess the feasibility of BC to enable end-to-end supply chain (SC) and to develop a tentative methodological framework of the BC level of success in SC context evaluation. The pilot shows that BC provides convenience in using a unified information system for different stakeholders throughout SC for more efficient and secure data exchange. A future understanding of the importance for BC technology use, as a traceability provider from the perspective of a final customer, is detected as a path for further research.

Keywords: Blockchain technology, Methodological approach, Supply chain management, Traceability.

1 Introduction

The interest in disruptive technology solutions for business processes is growing rapidly. Taking into consideration unforeseen emergency events of 2020, the digitalization and efficiency of operations is emergent as never before. In regard with emergency events [1] highlight the main criteria of supply chains: they need to be trustworthy, transparent, and share accurate real-time information, to assure the safety of global populations. The global supply chain is an industry, that is running two-thirds of the global economy [2], bringing to consumers everything that we eat, wear and use in everyday life. One of the most promising and disruptive technologies that has the potential to transform and improve supply chain activities is Blockchain [3].

Blockchain (BC) is an emerging technology, with potential applications to everyday life, from digital identity and voting to healthcare and legal contracts [4], [5]. The distributed nature of this technology, persistence and immutability of its records, and the ability to execute decentralized logic through smart contracts make BC-based products and services significantly different from those previously developed and based on the Internet – especially for sectors related to Industry 4.0 and supply chain [6]. BC is expected to become a “next holy grail for the enterprise”, as it holds enormous potential for supply chain (SC) transformation, among other areas, in the ways of production, orders performing, transportation, delivery and consumption [7]. However, with a few exceptions, SCs are not considered to be a priority on the agenda of most countries with BC initiatives, even though interest is very high [8], empirical research is very limited due to the lack of knowledge among professionals about the potential of this technology [9].

In the adoption of BC in Supply chain management (SCM) [10] argues that all must start with the answer to two questions: “What to adopt” and “Where to start”. Under the umbrella of the first question, [11] discusses and argues in favour of adopting a use case (which would be further developed into a pilot), nonetheless the second question still requests more detailed analysis. [12] suggest a framework for the mindful adoption of BC, which was extended by [11]. Further [11] proposed a guide for the “mindfulness of technology adoption” under the context of blockchain. Nonetheless, a more detailed methodological framework of how to assess those pilots and their impact on B2B and B2C is still lacking.

While discussing the main advantages, constraints and resistances of BC technology use in SCM, the purpose of this article is to develop a tentative methodological framework of how to assess the level of success of BC technology in SC and the methods that should be used in that assessment.

The food industry has experienced many quality drawbacks in recent years. Public distrust in the provenance of seafood and some conservation operations is growing [13] and BC technology might be helpful to overcome such distrust. As so, following on [12] and [11] suggestion of starting the adoption of BC in SC with use cases and pilots, this article will focus on the specific SC for one product - fish. Such a product, with fragile quality and high value as fish, shows to be a good example for a pilot. Consequently, the more detailed goal of this article is to assess the impact of the adoption of BC technology in SC trust in the fish industry. This paper will focus attention on traceability feature of BC technology, as well as the recognition of this attribute in the B2B relations in the SC together with the trust of the final customer in the product available. The need to conduct such research has already been stressed by [14] but to the best of our knowledge is yet to be accomplished.

The novelty of the application of BC technology in SC justifies that a case approach is adopted [15]. The pilot of a Portuguese fish sector SC will be explored to develop the methodological proposal to assess the impact of the adoption of BC technology in SC trust.

To fulfil the proposed goal, this research is based on existing literature on the topic as well as on interviews with key elements in the case SC. For confidentiality issues, the identity of the focal company in the pilot SC will not be disclosed and will hereafter be identified as Company X.

This paper is built as follows: chapter 2 will present some of the acute literature on the topic, mainly highlighting BC characteristics, application and the adoption models, potential and main challenges to SCM, with the focus on traceability feature of BC for food SCs. Chapter 3 will give a brief understanding of BC initiatives in Portugal and chapter 4 indicates a methodology that was used for this article construction. Chapter 5 introduces a pilot of CompanyX for the fish sector in Portugal, describing also the key management, blocks building and traceability processes, also discussing the assessment of the BC impact use in the pilot SC. Chapter 6 provides conclusions and paths indicated for future research.

2 Literature review

2.1 Blockchain technology and its features

Blockchain technology, also defined as an encrypted digital ledger [16] is based on a decentralized peer-to-peer system [17], that is able to create a continuous, visible and sharable record of products transactions and movements around SC in a distributed manner [18]. BC is a set of chain block, that altogether represent a permanent and inviolable sequence of records and transactions that can be verified in the future. Keys and encryption secure the process, and each stakeholder is identified by their key [19]. This network is build based on the consensus achieved by different voting mechanisms and the chain is extended with a new block when the majority of participants agree with it. [20].

Operations within BC are fully decentralized, and do not rely on an intermediary because all the transactions are being verified with smart contracts [21]. Unique features of smart contracts, such as automated process and tamper-proof system [22] together with the distributed nature of BC, improves upon automatization of ownership value and overall synchronization of business operations [23]. Smart contracts assumed to play a crucial role in partnership efficiency - since information is immutable, it leads to transparency and improvement of SC collaboration [24].

Due to self-executing codes, that are preventive to tampering or corrupting the execution of a given contract, every party is an equal custodian of the contract terms; which saves both costs and time in terms of contract revision, registration and verification. [22]. However, building a high-quality smart contract is even more challenging than creating a traditional one, since experience in this field is not so widespread yet [2] and as a result, poor coding of smart contracts leads to problems [25].

2.2 Blockchain technology for supply chain management

By its nature, BC is increasing transparency throughout the SC, in this way providing reliance and confidence of products' provenance [9]. These encrypted ledgers provide a unified variation of truth through consensus protocols [26], thus enhancing the performance of SC that does not need to establish trust relationship among actors since every participant is a keeper of all information flow existing around SC [22].

Transparency of information regarding products and processes empowers suppliers to get engaged with further activities and decisions, such as strategies development and innovation support [27].

At the era of the digital economy, SCs are still cyber-vulnerable: they are subjects to attacks due to their insecurity and are challenged with issues of trust both among suppliers as well as between supplier and consumer [28]. It is claimed, that BC has an enormous potential to decentralize traditional SC and generate new networks of value combining it together with additive manufacturing, artificial intelligence and Internet of Things (IoT) [2].

BC IoT framework is expected to be a key driver that will boost SCM to the next level of analytics, enabling data democracy, and thus improving performance and productivity [7]. So, the next step of the digitalization will be the transformation of industrial companies, enabling the exchange of data and services between them, and implementation of smart contracts as a unified tool for the value transfer. BC implementation is potentially applicable to any sector from construction engineering [22] and parking spaces collaborative gamification [29] to diamond authentication [30] and the music recording industry [31]. BC applications are commonly implied to be used together with IoT solutions, as for instance using BC as a decentralized platform for IoT-based low-cost smart meters for energy consumption [32] or for handling charging processes of electric vehicles through mobile application [33]. BC use is "only limited by our imagination" [2]. One of the best-known logistics blockchain effectuations is the collaboration between IBM and Maersk – the use-case for container shipping [17]. Walmart is testing BC for food SC [2], some studies focus on conceptual models' applications, the case for agro-food is explored at [34], electronic components at [35]. Safety is also an issue explored in the food business with [36]. General applications discussion is performed at [37]. Also, wine traceability is studied at [38] and for vegetables at [39].

2.3 Adopting blockchain in supply chains

In the context of BC technology adoption to SCM and logistics, [12] completed four mindful dimensions of technology adoption by [40,41] and introduce the fifth one, those dimensions are as follows:

(1) *Engagement with the technology* – Are the technological features named clearly?

(2) *Technological novelty seeking* – Is there reasoning for the necessity of blockchain technology or can the business problem be solved with existing technology?

(3) *Awareness of local context* – How specifically will the use case fit into the supply chain context?

(4) *Cognizance of alternative technologies* – Are alternatives considered?

(5) *Anticipation of technology alteration* – Are use cases adaptable?

The listed dimensions were considered under the lens of key high-level SC objectives presented earlier by [42] which include cost reduction, speed, dependability, risk reduction, flexibility and sustainability. Since [12] were concerned with a threat of "a solution looking for a problem", [11] expanded those five principles and added one more dimension, which is a "contribution to high-level supply chain objectives". This dimension contributes to eliminate the risk of the unsuitability of BC technology in a potential use-case [11]. By virtue of this substantial dimension, in future, it will save resources and time for SC that will search for latter-day technology to implement.

2.4 Constraints of blockchain technology for supply chain management use

Undoubtedly, BC technology looks very attractive to scholars and practitioners, however, there is still a vast number of challenges for its integration into SC context. Numerous institutional, infrastructural, technical and regulatory challenges need to be embraced before BC-based solutions can reach their maturity stage [43]. Among others, challenges such as organizational readiness, scalability, technical expertise, [44] high cost of the technology and further regulation issues [45] may arise when implementing BC in the SC. Security issues of open access BC [46] and management procedures for BC used by multi-actor SCs [47] need to be addressed in future studies. A lot of BC initiatives have difficulties in emerging from the pioneering phase [48] and in the majority of cases, organizational changes are needed to be undertaken before this technology can be successfully adopted [49]. In general, all these constraints of a BC implementation imply a high risk of emergent technology adoption from scratch that also involves big costs [43]. Moreover, the literature on BC technology for SCM needs “theoretical substance and a theoretical foundation” [50] that could refine the understanding of such a novel phenomenon [25]. BC is claimed to be useful for traceability of goods within SC, boosting thus the overall transparency, however, organization and preparation of SCs themselves is essential before BC can be implemented [49].

2.5 Traceability for blockchain-based supply chains

BC is assumed to shed light into industry sectors’ (e.g. food) complexity in terms of full traceability of SC networks [27]. Most of traceability standards are concentrated on the ability to follow the main characteristics of a product from origin to the final process destination throughout the SC [49]. The Typical food SC consists of many members, among others suppliers, producers, manufacturers, distributors, retailers, consumers and certifiers; when connected together on a unified BC platform, every one of them will be able to update, add and check the real-time information about products [51]. Since every transaction is visible in the BC ecosystem, it is easy to trace backward of the supply of each product or service with authenticity from a compliance or quality assurance perspective [22]. Traceability feature of BC brings the knowledge of the authenticity and origin of a product, as well as footprints of products’ locomotion throughout the SC, bringing both commercial benefits in terms of brand reputation and serious safety measures [52]. Business requirements for BC-enabled traceability systems from the SC’s focal companies view were addressed in [14] claiming that specific business requirements and technological evaluation of the business case development should be accurately analyzed.

Some of the main challenges in SCM is product traceability and supplier dependability, satisfaction and trust; it will impact on the performance of the entire SC [53].

Issues, such as traceability of products supplier dependability and end-to-end time and quality of service are all crucial for the success of SCs.

It is clear in the literature, that traceability is a relevant issue to the several parties in an SC. However, traceability may not be recognized for having similar relevance for every element of the SC. The extend of this relevance is yet to be discussed, as well as the impacts or utility of traceability.

2.6 Traceability for food supply chains

Food quality is a big concern to society, thus of us, and assuring quality throughout global and complex supply chains is very challenging for food and beverage industries. At the same time, issues like legal regulations, food standards and corporate social responsibility criteria, including also environmental sustainability concerns, should be highly considered [54]. Thus, product traceability from origin producer to the final consumer is an essential problem to solve. BC disruptive technology can give solutions to this problem by managing the identity of process stakeholders and associate immutable transaction block of product transactions, allowing food retailers to keep a track and react rapidly for recalls, assuring, thus, safety issues and reducing the chance of illnesses caused by food [18]. BC and smart contracts can handle this transaction in an SC process without a central control entity.

According to [55] BC-based solutions for food SCs could be crucial in pandemic times, as complex and lengthy overseas SCs made it challenging for agricultural exporters to get the same guarantees and maintain cashflow. On the example of Australia’s surplus of seafood and agriculture, that Chinese market used to order, [55] explain that BC-based solution could give an ability for every participant of an SC to confirm the type of products shipped, track where it is at the real-time, and whether it has been stored under required conditions (e.g. temperature, humidity etc.).

The food transportation process is essential to be the focus on the safety, quality, and the certification of producers in a global market driven by profit—the rising number of problems related to food safety and contamination risks [56]. Product traceability from origin producer to the final consumer is an essential problem to solve. BC disruptive technology can give solutions to this problem by manage identity of process stakeholders and associate immutable transaction block of product transactions [57]. BC and smart contracts can handle this transaction in an SC process without a central control entity.

Attributing food traceability as part of logistics management highlights the fact that quality assurance, food safety and overall efficiency of SC depend highly on logistics operations [49].

3 Use of Blockchain in Portugal

The European Commission recognizes a potential that BC technology is able to offer to improve European industry; like this, any type of companies, from start-ups to giant corporations could transform their operations towards decentralized and transparent digital services [58]. In December 2019, the European Commission launched an open market consultation that is looking for improved and innovative BC solutions for the future evolution of the procurement process [58]. Governments should keep on creating a firm grasp of legal and regulatory issues for BC, at the same time supporting use cases of this technology in SC context [59].

Since BC technology still resides in its infancy, Portuguese companies that are working with this technology have been formed mainly by young graduates. Examples of these are companies such as:

- *Public Mint Inc.* - presented as: "the first fiat-native blockchain settlement layer for programmable money" [60].
- *Genesis studio* - created for the full adoption of BC and modern distributed accounting technology (DLT) [61].
- *Taikai* - a start-up that creates challenges between large companies and BC start-ups. Taikai is a challenge platform that uses BC; it has raised 350 thousand euros and is headed by Mário Alves, who left the bank to lead the project [62].
- *WalliD* – this Portuguese BC start-up received an investment of 600 thousand euros. Among the investors is the National Press - Casa da Moeda. WalliD developed an identity registration and management tool in the Ethereum BC platform. Through the WalliD tool, a user can store his/her identification documents in a BC-based digital wallet. This information can then be used to validate the person's entity in the services of companies and organizations that adopt the WalliD system [63].
- *Bitcliq* - this Portuguese startup is the first worldwide BC market for fish trade, connecting fishing fleets with buyers and allowing the purchase of fish when they are caught at sea by retailers and restaurant owners. In addition to connecting fishers to buyers, the platform also allows full traceability from the catch location to the table, which is becoming essential for an ecosystem with ever lower prospects due to illegal fishing practices and ocean pollution [64].
- *Zenithwings* - is developing a BC solution to help protect wine producers and consumers by allowing digital certification and product traceability [65].

As in the rest of the world, there are no known companies in Portugal that have yet implemented BC technology in its broad spectrum; it is mainly used for initial coin offerings (ICO) nevertheless it is expected to bring drastic change to both public and private entities [66] and disrupt SCM.

4 Methodology

This research aims to develop a tentative methodological framework of how to assess the level of success of BC use in SC. The novelty of the topic justifies that it is addressed using a case study approach [15]. Hereafter, the case study will be called the pilot.

Following [15]'s recommendations, the quality of the results produced from the case study depends on the process of conducting it. Consequently, in our research focus is on defining the process, which will respect the guidelines suggested by [15].

For confidentiality reasons, the name of the focal company of the SC considered in the pilot will not be disclosed; it will be addressed as "Company X".

Data for the different stages of the case study was collected using semi-structured interviews to key flow managers of fish in Company X. These interviews were conducted at the location of the central processing point of the company, and followed a detailed guided visit of the facilities and the end-to-end process during working hours, which added observation as a data collecting tool for building the case. Several visits (four) to the retail points to observe final customers allowed identifying what they read and ask about the product before buying it (in all the selling points there was both pre-packed fresh fish and fish to be sold in bulk).

5 A pilot for the fish sector in Portugal

5.1 Addressing the use of blockchain

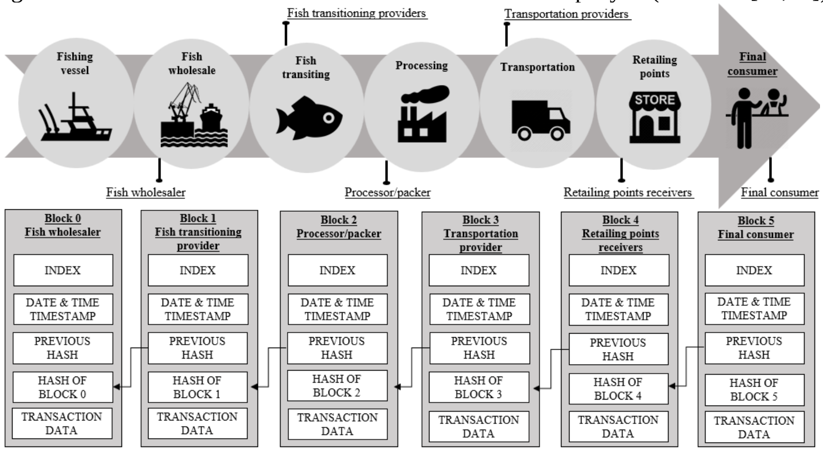
Fishing as all products in the SCM process changes owners, and several companies are involved. One big issue among different stakeholders is that they have different information systems, and data exchange is complicated because of the trust and security process. BC can be a solution to overtake this problem, and thus creating a solution of traceability. We implemented a concept proof of Hyperledger Fabric's framework to keep track of each part of this process. Commercial BC can also be used, but for this concept proof, open sources create flexibility, and available libraries created flexibility towards our proof of concept implementation. So, we implement a simplify Hyperledger with associated channels (chains) that take the data from different information systems and creates the possibility of transaction visibility. From this, a set of an independent chain of transaction blocks containing only transactions for that particular channel is created.

Smart Contract allows defining conditions for transactions process and fish asset change of owner, and this result in changes to the ledger. The ledger contains the current performed transactions signed to each stakeholder. This is a network that is responsible for maintaining a consistently replicated ledger. This data is stored in a database for efficient access. Currently supported databases are LevelDB and CouchDB. Membership Service Provider (MSP) manages identity and permissioned access for clients and peers.

Since we have data from the SCM of fishing in Portugal, we use this data to create a laboratory simulation of all fish SCM in Portugal that we will describe in this chapter.

Company X is one of the leading retail groups in Portugal. This exercise complies the SC of Company X from the fishing vessels all the way through different parties that support the physical flow of the fish to the end-user. The global structure of this SC is shown in Figure 1.

Figure1. Overall fish sector SC and BC architecture for Company X (based on [49,67])



The fresh fish is captured in the ocean and brought to land in fishing vessels. The place and origin of the fish need to be clearly identified to assure quality, so the traceability of the product needs to start at the fishing moment. Traceability needs to be assured to the point of product availability, so all the entities that support the physical flow of the fish are considered. Every link in the SC can be a source of disruption.

The BC traceability system is based on a set of signed transaction performed by the stakeholders from:

- **Fishermen (fishing vessels)** have a Vessel Monitor System (VMS) that register GPS position at sea. From a Portuguese project SeaItAll a National project from a Portuguese company Xsealence [68] it is possible from video cameras to identify the fish type. This information with date and time is transmitted to a central management control system.
- **Fish wholesaler (Docapesca)** receive fresh fish from vessels and fish trade is performed here in Portugal. In other countries, the equivalent process and institutions are involved. Current BC proposal starts here as Block 0, as can be seen on Fig.1, and allows traceability, creates interoperability among different information system involved, creates trust and security and creates control to avoid the illegal fishing process. VSM (GPS position of the fishing process), fish type, vessel plate, date and time are associated. Also, at the sealing process is associated with weight and any particular information. This information is collected from this central management system and associated in BC with fish buyer key in the BC chain. This is the first register at BC, and we also start the *traceability process*. Example of this is:

```
var sardine = { id: ‘0001’, holder: ‘DocaPesca’, location: { latitude: ‘40.40238’, longitude: ‘2.145328’}, when: ‘20190630123546’, weight: ‘20Kg’, vessel : ‘9523E’ }
```

- **Fish transitioning providers** are responsible for receiving fresh fish from Docapesca and transit it to further processing and packaging. The information that should be recorded at this stage is receiving date, storage details, processing, sampling, analysis of the bulk fish (e.g. big fish like tuna could be divided in smaller parts), and the dispatch date/time. If the bulk distributor performs the combination process, the information also must be recorded in the chain. This can be the output of smart contract negotiation, but for this validation purpose, we check only fish owner change in BC and associated transaction with price, data and other relevant information. This transaction generates a new block linked to the previous through the hash.

- **Processors / packers** are responsible for actions like splitting fish (e.g. big fish like tuna) and pack then. Initial fish product can be split here, and again a new chain is created signed by processor entity if it is the case. New register is raised. Taking into account previous example, this block could be the sardine packing in packs of 1Kg. New data stamp is associated with information about the packing company.
- **Transportation providers** are responsible for further movement of goods, and again, a new transaction is raised linked to the previous by the hash. Information includes date, time, transportation conditions, start and endpoints, number of km, stakeholder intervenient.
- **Retailing points receivers** get product and then creating a new block of transaction that is linked to the previous block. Data, time, location, entity are crucial to indicate and insert into the system at this point.
- **Final consumer** when buying the product, the new transaction is generated, and end customer is able to trace back the whole process of the product that is intending to buy.

5.2 The relevance of adopting blockchain technology in Company X supply chain

Following recommendations jf [15] and [11] framework, the pilot should start with the analysis of the relevance of the use of BC in the specific SC, therefore there should be an initial approach to the SC under analysis and the product to be addressed. Prior to the extension [11] introduced to [12] proposal based on [42], this overview can be achieved with a simple mapping of the supply such as the one provided in Figure 1.

This mapping is relevant to identify the stakeholders in the SC process. A stakeholders analysis matrix should be conducted to identify their power and interest in being part of the SC and adopting BC. This would allow identifying the potential fragilities in the project but also potential allies. Those who recognize the potential in BC use to leverage the SC objectives should be identified for initial use cases. Interviews with decision-makers at each stakeholder should be the main data source to conduct the data collection for this stage. From this point forward, the approach to the critical SC objectives and the criticality of each stakeholder would be linked.

With the ever-growing challenges of global warming and scarcity of natural resources, it is very likely that not many years from now the origin of the fresh fish might change. New fishing companies, new fishing markets, or movements, such as aquaculture, are likely to consequently enter the SC, adding or replacing the current ones. These changes in the SC need to be considered as well as the new elements of the SC might have different approaches to the use of BC in SC and lead to a shift in the SC strategic goals.

The second stage would relate to the engagement with technology not only in the overall SC, but mainly at each stakeholder. BC technology will allow traceability if the different elements are linked, available and willing to share information, so their technological engagement needs to be considered. This approach will be conducted with an assessment of the technological options used by each stakeholder, its ability to communicate to other stakeholders, and their willingness to conduct the necessary adjustments.

Stakeholders, according to [12] and [11] proposals, need to develop reasoning to the adopting of BC technology. Without it and the shared knowledge of its impact on the SC goals, commitment might decrease. Technology adoption process itself lies in engagement from executives and main stakeholders' proposals [11]. Meetings are a method to assure this step of the process. It can be conducted at more than one level: initially with promoters of use cases and latter with the remaining stakeholders, using the results of the use cases as an argument.

By conducting the previous step at two levels, first with use cases to show the potential of BC and then involving all stakeholders in the impact, the fourth step of [11] proposal is anticipated and conducted along with the third one. Differences of context between stakeholders will need to be addressed as the impact of BC can differ. For instance, the reception of fish from the vessels and transportation, by their nature, show more exposure to traceability fragilities while the processing and the retail points might be less exposed.

Next step in this framework is to make sure that BC technology is the best solution. If alternative technologies show the potential to produce better results for the SC in terms of its strategic goals, those should be considered. Nonetheless the decentralized nature of BC should be considered as a relevant safety issue in a fish SC such as the one in this pilot.

The technology landscape is evolving and alterations to technology need to be anticipated [12]. The use cases in the pilot need to consider these possible adjustments. Alternative solutions need to be planned as to assure SC resilience.

5.3 Key management and identity management – Building the blocks

Each stakeholder should identify and keep secure a key to sign their transaction. On the first place, to ensure confidentiality, a common secret key is distributed among all entities in the system. Each participant in the system needs to generate a pair of the public and private key before starting its operation. Thus, the transaction block may contain information in the form of both plain text and ciphertext. The SC starts at the fishing vessel, and the fisherman generates the genesis block and adds the required information. Initial block (Block 0) is generated at the selling process in Docapesca. This entity signed with their key and certify that this is a legal fishing process. The block is verified by the majority number of miners in the system before the next block being added to the chain. An ID number certify transaction order. This procedure is followed by the party that transits fish to the processing point, processor/packer, transportation unit that provides logistics to retailing points, and each retailing point, in order to include their transactions in the chain.

This basic BC is a chain of blocks with the following: 1) Index; 2) Timestamp with date and time; 3) Previous Hash to link to the previous block; 4) Current hash; 5) Data about the transaction (see in Fig.1).

So, BC is a set of information about transactions, secured by hash (a string of numbers and letters) and connected to the previous (order in it), and approved by all. Each time there is a need, stakeholders can browse for chain block and with the appropriate key that can check product history in a controlled decentralized process.

5.4 Assessing the impact of BC used in the Pilot SC

Even following [12] and [11] proposals, there is no guarantee that the internal customers and the final customers will recognize the impact of the use of BC. The technology will not be recognized as valuable by these customers unless their own goals are met. Consequently, the goals for both the SC parties and the final customers need to be identified. If for the SC parties those were already identified under the scope of [11]'s first step for the consideration of adopting BC, the relevant criteria for the final customers' needs still to be assessed.

Although it is easier to guess the final customers relevant criteria than to really identify them, the real criteria can differ from what the provider expects. As so, conducting an inquiry on what is relevant to them and the relative importance of those aspects is required. For Company X and the fresh fish, it would be, for instance, the origin of the fish, the date of fishing, the continuity of the cold chain, among other issues that the end customers might want to highlight.

Company X set as goals for the fish SC the reduction of time to market, improvement of quality (of the service provided to customers, of the physical quality of the product, of the reliability of the information - trust) and reduction of operational costs, which are goals difficult to fulfil at the same time. From the SC party's perspective (excluding the final customers), the pilot needs to be assessed based on the improvements it produces at these several levels: operational costs, time to market reduction, freshness of the product, reliability of the information available, all assessed at each party in the SC. If the first two criteria can be assessed quantitatively, the last two require a more qualitative approach. As so, the success of the adoption of BC in SC for fresh fish, due to the fragile nature of the product, needs both a qualitative and a quantitative approach.

To conduct this assessment, each fish assembly package should have a unique identification number (e.g. a barcode) that would be attributed at the vessel. After certifying the fish (or fish batch), it would be the unit that would flow through the SC down to the retail point and sell to a final client. All the parties involved in this chain can verify the validity of the organic certificate issued by querying the BC. When the fish changes ownership, this is recorded in the BC as well, and this enables anyone to check the provenance chain of the fish and all product information. By being recorded on the BC, every party validating the certificate is able to access this information. An auditor is also able to revoke accreditations on the level of an accreditation-body.

Although trust is difficult to assess, especially at the level of the end customer, a BC app could be developed to provide the traceability of the product (its origin, where it passed through to get to the retail point, where it stopped, how long it was at each link of the SC etc.) as well as to collect data on the satisfaction level of the customer with that availability of data and the improved trust the customer has on the SC. As this improved trust can dictate choosing one retail chain over another one, this proposed approach can provide additional information about the success of the BC initiative.

6. Conclusion

In the light of current pandemic state, stricter measures are needed at each stage of SCs [69] for food provenance and safety. By initiating BC-based traceability process, SC actors can avoid fraudulent actions and potential corruptions, at the same time building trust with the end-customer by providing health and safety, that can be confirmed by the customer himself/herself. Such a disruptive solution has the potential to significantly reduce illegal fishing, thus keeping and even driving business value. Current risks in the SC that are associated with a lack of supplier accountability and transparency of processes, could be overcome by the implementation of a BC-based traceability solution.

Being able to monitor events, processes and important data associated with a product, BC thus enables a full backward trace audit of data and creates a permanent encrypted platform for transaction and record-keeping throughout SC [70].

Regarding the BC impact assessment for SC context, the extension of traceability relevance for each element of the SC needs to be further developed. Since trust is complicated to be assessed at the stage of the end customer, a BC app could be developed in future in order to provide the traceability of the product for the final consumers. However, [13] claims, that smartphones and BC alone are not enough for reliable tracking and monitoring of caught and processed fishes, thereby, other types of sensors and trackers, including IoT devices, remote sensors, and handheld DNA sequencers, could potentially help in overcoming this concern.

A possible extension of the [12] and [11] was detected as a consideration of BC adoption, as being a relevant and value-adding criterion for the final customer.

This pilot highlighted once again the emergence of the BC technology as a traceability and safety provider for operations and movements throughout SC's product lifecycle. At the same time, literature gaps and paths for future research were detected.

The use of a case study approach has some limitations, such as the difficulty to generalize findings. Nonetheless, the case is an example to support the development of the framework. Consequently, in further pilots or case studies with similar SC structure, the overall framework could be attempted.

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