BLOCKCHAIN: A TOOL FOR SUPPLY CHAIN CERTIFICATION

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ABSTRACT

Blockchain technology allows to develop product certification processes, offering greater guarantees on the history of food, from the collection of raw materials to the flow between operators in the supply chain and up to the final consumer. This new technology can therefore represent a strategic element for the agro-food supply chains (and not only). On one hand, in order to defend production from climatic variability, prompt action to manage production factors can be taken, as well as to contain costs and minimize production and environmental risks. Additionally, to guarantee brand safety and protect specific territorial features from illegal competition with counterfeit products. In this work authors introduce the Blockchain technology and its usage and implications for the supply chain certification. Initially its main aspects are illustrated together with its historical origins; in the next sections the specific issues related to supply chain and the certification of products are examined, and then we propose an adoption scheme of blockchain technology for fostering a sound and effective certification of the production in the entire supply chain.

Keywords: Blockchain, Traceability, Trustworthiness, Supply chain, Certification

1. INTRODUCTION

Blockchain innovation is surrounded by the fast-growing industrial ambience. The hype about this technology has to do with its effectiveness for achieving and maintaining integrity in distributed peer-to-peer systems, with the capacity of reshaping whole existing industries by disintermediation. In this system, each node maintains its own copy and, following the blockchain's consensus algorithm, all nodes reach one consistent version of the shared ledger.

The blockchain technology through decentralization, trustworthiness and collective maintenance ensures a reliable register of well-systemized information (Karikari et al., 2019). Taking into consideration all these characteristics of blockchain, it is a good foundation for industries to use in order to simplify product tracking along supply chain, certification process and establishment of new relationships.

In fact, currently the attention is focusing on the food traceability since there is an increasing need of certification of origin and quality of product. Thanks to Blockchain technology, all the players in the supply chain would no longer need to use "paper documents" or rely on central or third-party entities for the certification of the various information and documents produced during the different stages of the supply chain.

2. BACKGROUND ANALYSIS

2.1. The Blockchain Technology

The basic idea behind the blockchain technology was born in 1991, when Huber and Stornetta (1991) in their work described how to sign documents digitally in a way to be easily shown that none of the documents signed in the collection had been modified. This system was first used for digital currency in 2008 by an anonymous programmer Satoshi Nakamoto.

Blockchain (Prathyusha et al., 2018) is a peer-to-peer distributed database of transactions (ledger) secured by cryptography. Transactions are registered in a continuously growing list (chain) of records (blocks) which are append-only (it is possible to write a new block at the end of the structure only) and immutable (or at least very hard to change). The blockchain can be updated only via agreement among peers (consensus). For obtaining identical results when aggregating transactions, it is mandatory to preserve the order in which transaction data are added to the history. Any transaction not being part of that history cannot be trusted on.

In order to maintain integrity, only those transactions that are formally/semantically correct and authorized, get added to the blockchain. Before adding a new block into the blockchain, it has to be validated through the so-called hash mechanism. A hash function transforms any data into a sequence of fixed length figures (characters and/or bits), regardless of the size of the input data. Cryptographic hash functions create a (quick) digital digest for any data in deterministic form (same input => same output), with pseudorandom behaviour (a little change in input data turns into a big change in the output digest) and one-way usage (no reverse-engineering; it is not possible to get the original data from the output digest). If the data had been changed, both, cryptographic hash value and data location, would be different and the hash reference would become invalid.

2.1.1 Blockchain data structure and immutability

The first block of the chain is called the "Genesis block". Each block stores the following information:

- **Index**: the position of the block in the chain (the genesis block has index 0).
- **Timestamp**: the time when the block was created (used for keeping the blockchain in the correct order).
- **Hash**: a numeric value that uniquely identifies the block's data (the digital fingerprint of data) and has the following properties: Fixed length (typically 256 bits); Easy to compute; Not reversible (it is not possible to get the original data from hash); If data changes, hash changes (in particular, small change in data leads to big change in hash).
- **Previous hash**: the hash reference of the previous block in the chain.
- **Data**: the data (transactions) stored in the current block. Changing the data will change the hash, so it become invalid. Subsequent blocks will also be invalid, leading to a cascading invalidation of blocks in the chain.
- **Nonce**: the number of iterations needed to find a valid hash, i.e. a hash with a required predefined number of leading zeroes, called *difficulty* (3 in the example shown in fig. 1).

Figure 1. A hash value (with difficulty 3)

The hash of the current block comes from the combination of its index, timestamp, data and nonce and the previous block's hash. Mining is the process of finding a valid hash for the block. A new block being added to the blockchain needs to meet the following requirements:

- Block index = latest block index + 1;
- Block previous hash = latest block hash;

- Block hash meets difficulty requirement (no. of leading zeroes);
- Block hash is correctly calculated.

Different peers on the network are simultaneously trying to add blocks to the blockchain. For this reason, new blocks need to be validated before becoming part of the chain. Peers ask each other to find who has the most up-to-date blockchain version.

If a block is modified, it and its subsequent blocks become invalid and are rejected by the peers on the network. Earlier blocks will be harder to alter because there are more subsequent blocks to re-mine. The only way to mutate a block would be to mine the block again, and all the blocks after. Since new blocks are always being added, it's nearly impossible to mutate the blockchain.

2.2. Food supply chain: the risk of fraud and tracking production through Blockchains

The interest in the concept of the Supply Chain has steadily increased since the 1980s, when companies from different sectors have verified the advantages resulting from the construction of collaborative relationships within and outside their own organization. According to Van der Vorst *et al.* (2007), the supply chain is a sequence of processes (decision-making and executive) and flows of materials, information and money, which occur at different stages of the journey of products and services from the point of production to the point of consumption and cross the borders between the organizations involved. La Londe & Masters (1994) proposed and Lambert et al. (1998) follow a slightly different logic, more focused on the role of active subjects in the supply chain. It identifies the Supply Chain as a set of enterprises or identities through that brings products or services to the market.

In today's constantly transforming world, agriculture management as almost all other fields is becoming more complex. A more frequent need for intermediaries causes the supply chains to get longer (Mylrea & Gourisetti, 2018). Hence, the number of documentation and their copies for all involved parties increases that makes it challenging to understand the origin of products (Mei & Dinwoodie, 2005). Despite the fact that agri-food supply chains are already digitalized (cloud computing, artificial intelligence, internet of things), there are a lot of remarkable inefficiencies in the farming operations, distribution and selling. Globally, the cost of food fraud is US$40 billion every year (PWC, 2017). From a process point of view, companies still suffer with a lack of integration and organization of services, especially regarded to certification processes. The necessity of these companies concerns the simplification of the control and certification procedures and the reduction in the hours/person employed for this activity. A further critical element that can be found within the organic supply chain is represented by the problem deriving from the conflict of interest generated by the controlled-controller relationship that has led over the last few years to a loss of reputation in consumers related to the certification system and the organic supply chain as a whole.

So, traceability becomes the crucial factor in agri-food supply chain, in terms of the ability to trace and follow the history of final product in the supply chain, and possessing necessary information on all stages of production process, warehousing, distribution and trade (Aung & Chang, 2014). It will minimize possible human error reducing the steps and procedures by directing the company and the certifier towards a process automation. The blockchain, in this sense, is opening a world of opportunities that will offer a huge sustainable competitive advantage.

IBM demonstrated the use of blockchain as a fresh food tracking system for Walmart (Hackett, 2017), tracing the movements of each individual product from harvesting to packaging, from cold storage to sorting centers. In Italy, Barilla has adopted a similar process (Morabito, 2017; Petek & Zajec, 2018) to follow the growth of basil plants used for pesto. It starts with sowing and continues with delivery to haulers up to the factory where the basil is transformed into pesto. Everything is under control and not a single batch can go unnoticed by the company. The aim is to strengthen the image of quality of the raw material along the entire chain and the anti-counterfeiting control. The interest in Blockchain technology is stronger in the case of Protected Geographical Indication (PGI), Protected Designation of

Origin (PDO) and organic products since the detailed information about steps passed by the product gets crucial importance.

3. SUPPLY CHAIN TRACKING SYSTEM BY BLOCKCHAIN TECHNOLOGY

Carrying out a comparative analysis of supply chain efficiency ex ante and ex post the IT technology introduction, La Sala et al. (2017) argue the importance of efficient use and sharing of information and introduce the scheme of the IT system adopted (fig. 2). The scheme shows that the interaction between different stakeholders (supplier companies, farmers, processing companies, distribution company, retailer stores) of the industry is much more simplified using advanced technologies.

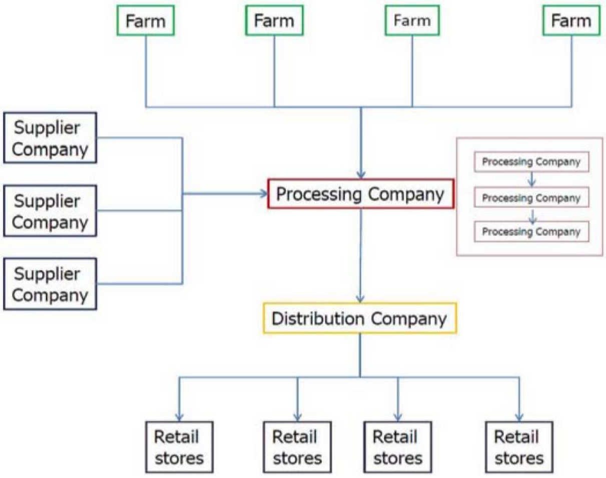

Figure 2. Scheme of the IT system adopted

Started from this scheme, authors propose the model where authenticity of all information is proved by Blockchain technology. It is supposed, that all supplier companies and farmers use Blockchain for registering the transactions. So, all the activities carried out by each stakeholder are registered on the blockchain: after the activity has been done, the information is declared, then proved and protected by hush. Thus, the information provided by supplier companies and farmers are trustful as falsification is almost impossible. Subsequently, processing companies get trustworthy information about input such as the geographical indications, weather conditions, soil management, seeds' nutrients etc. Then similarly they register techniques and technologies of processing and add new block to a chain (or make new Genesis block for specific product as it is shown on the fug. 3). Next, distribution company describes the transportation conditions, safety, temperature, vehicle, delivery and adds new block. After that, retail stores register some other information like delivery details, storage, safety and additional block is constructed. Finally, as consumers as regulatory authorities can track all steps passed by specific product simply by scanning its QR code.

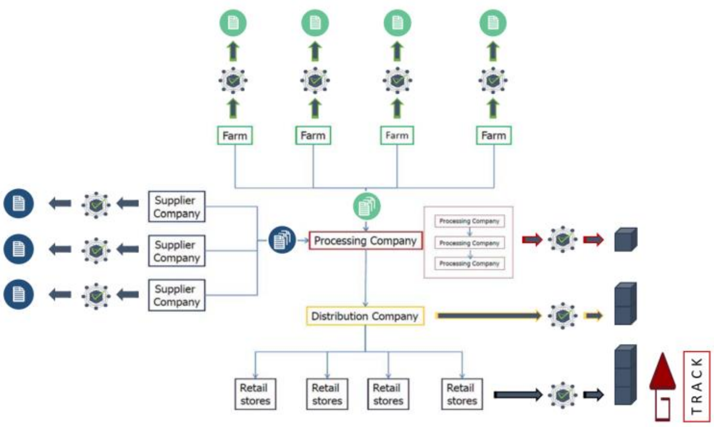

Figure 3. Supply chain tracking system by Blockchain technology

4. Discussion

In the current agri-food market, there is the increasing need to certify the origin and quality of products using a new traceability model capable of setting a quantitative and qualitative model of information shared along the supply chain. In this way, the problems related to food safety would be solved, at the same time ensuring the maximum transparency for final consumers and regulatory authorities. This requirement is even more important in the organic farming sector where the control and certification of all stages of the supply chain become important to guarantee compliance with the certification schemes that the correct agronomic and processing practices related to organic farming are done.

Blockchain technology would allow agri-food information to be shared in a reliable and secure environment, also guaranteeing its immutability. All the players in the supply chain would no longer need to use "paper documents" or rely on central or third-party entities for the certification of the various information and documents produced during the different stages of the supply chain. Before buying a product, consumers will be able to verify all the data and consult the certified documentation: not only the origin, but also, for example, if the frozen food has been transported safely at the right temperature.

5. Conclusion

Blockchain technology improves the monitoring of production process and reduces the work intensity necessary to guarantee the quality and certification processes. A further effect on the production processes and transformation is giving the ability to all the players in the supply chain to participate in a shared manner in the construction of quality processes. The implementation of the technology and related management model guarantee the nodes mapping of the supply chain where the gup takes place. Through this mapping it will be possible to provide the data for better control and for improvement of the processes. The monitoring will allow to identify any inefficiencies in the supply chain and the consequent intervention for their minimization. There will be an intensification of information exchanges between operators and consumers which will determine an increase in awareness of the final consumer about the organic product and the value of the supply chain processes.

The limitation of this paper is its descriptive character and the future research plans of the authors is to examine the blockchain technology in practice.

References

Aung, M. M., & Chang, Y. S. (2014). Traceability in a food supply chain: Safety and quality perspectives. *Food Control 39*, 172-184.

Hackett, R. (2017). Walmart and 9 Food Giants Team Up on IBM Blockchain Plans. *Fortune.*

Karikari, A., Zhu, L. & Dara, R. 2019, "Blockchain: The next step in the development of the Internet of Things", *2018 IEEE 9th Annual Information Technology, Electronics and Mobile Communication Conference, IEMCON 2018*, pp. 341.

Katz, J., Menezes, A. J., Van Oorschot, P. C., & Vanstone, S. A. (1996). *Handbook of applied cryptography*. CRC press.

Ku, R. S. R. (2017). The creative destruction of copyright: Napster and the new economics of digital technology. In *Copyright Law* (pp. 207-268). Routledge.

La Londe, B. J., & Masters, J. M. (1994). Emerging logistics strategies: blueprints for the next century. *International journal of physical distribution & logistics management*, 24(7), 35-47.

Lambert, D. M., Stock, J. R., & Ellram, L. M. (1998). *Fundamentals of logistics management*. McGraw-Hill/Irwin.

La Sala, P., Faccilongo N., & Fiore M. (2017). Integrated management of the PGI 'Matera' Bread chain. World Review of Entrepreneurship, Management and Sust. Development, 13 (5/6), 665-683.

Mei, Z. & Dinwoodie, J., (2005). Electronic shipping documentation in China's international supply chains. *Supply Chain Management. Vol 10, 3*, 198-205

Morabito, V. (2017). Business Innovation Through Blockchain. *Cham: Springer International Publishing*.

Mylrea, M. & Gourisetti, S.N.G., (2018). Blockchain for Supply Chain Cybersecurity, Optimization and Compliance. *Proceedings - Resilience Week 2018, RWS 2018*. Article number 8473517, 70-76

Nakamoto, Satoshi. (2008). *Bitcoin: a peer-to-peer electronic cash system*. https://bitcoin.org/bitcoin.pdf.

Petek, I., & Zajec, N. (2018, April). Collaborative Intelligence and decentralized business community building–Potentials in Food/Nutrition sector. In *2018 IEEE 34th International Conference on Data Engineering Workshops (ICDEW)*. IEEE.

Prathyusha, T., Kavya, M., & Akshita, P. S. L. (2018). Block Chain Technology. http:://academicscience.co.in

PWC. (2017). Food fraud vulnerability assessment and mitigation. *Retrieved from Are you doing enough to prevent food fraud?: https://www.pwccn.com/en/migration/pdf/fsis-food-fraud-nov2016.pdf*;

Van der Vorst, J. G., Da Silva, C., & Trienekens, J. H. (2007). *Agro-industrial supply chain management: concepts and applications.* FAO.