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# Blockchain Technology in the Food Industry*

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*Abstract*

*This paper analyses how blockchain technology works in agri-food supply chains. It also intends to identify the benefits and limitations associated with the potential widespread use of this technology to improve efficiency and sustainability performance. Despite the undeniable benefits of blockchain and the possible improvements to enhance transparency, reliability and accuracy of information, considerable challenges to its widespread adoption persist. The transformational potential of blockchain technology can be unlocked by: a) the creation of a pre-competitive space for unprecedented horizontal collaboration amongst supply chain actors to reduce cost and maximise benefits; b) the redesign of centralised governance systems of existing tracking and information-sharing platforms; c) the integration of blockchain and Internet of Things devices.*

**Keywords:** Blockchain; Supply Chain Transparency; Food Sector; Traceability; Sustainability; Global Competition

## 1. The Blockchain Technology

The blockchain technology was developed to underpin innovative financial transactions using Bitcoins, as a currency exchange and global payment system (Nakamoto, 2008) that bypass traditional financial intermediaries, such as banks. Transactions are validated by decentralising the network in which data is stored without requiring a trusted central entity. (Wang et al., 2018).

The widely accepted definition of blockchain is that it consists of an open, shared, decentralized and distributed digital ledger (i.e. a register of all payment transactions) in which the transactions and data relating to the parties involved are recorded and added in chronological order with the aim of creating permanent and tamperproof records (Nakamoto, 2008).

Blockchains are made up of "nodes" located on a communication network that uses some common communication protocols. Each time a transaction occurs, it is placed in a "block"; each block is connected to the previous and next one to form an irreversible chain in which transactions are blocked together (hence the term "blockchain"). Whenever a new record is verified and added to the blockchain, multiple copies are created in a decentralized way in order to create a chain of trust (Saberi et al., 2018).

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Edited by: *Niccolò Cusano University* ISSN: 1593-0319

Fortuna, F., & Risso, M. (2019). Blockchain Technology in the Food Industry, Symphonya. Emerging Issues in Management (symphonya.unicusano.it), 2, 151-159.

http://dx.doi.org/10.4468/2019.2.13fortuna.risso 

Blockchain technology does not require a central server to store and retain data. As long as the network maintains consensus on what transactions have taken place in the past, it acts collectively as a server to host data. (Hughes et al., 2019).

The world of connected sensors (Internet of Things, IoT) introduces the opportunity to certify events that happen automatically, allowing their active use through smart contracts that do not need a person or a notary to allow their implementation but self-execute when pre-established conditions are met. Moreover, with the blockchain, the data recorded by the sensors assume the typical characteristics of the blocks in the chain, becoming immutable and shared.

In terms of access control, blockchains can be public or private. In a public blockchain, transactions do not require any type of authorisation, and users can remain anonymous. Bitcoin is an example of a public blockchain. Each user can join without requesting the authorisation of other members; the network typically has an incentive mechanism to encourage participants to join the network. Unlike public blockchains, private ones require participants to obtain an invitation or permit to join. Access is controlled by a consortium of members or by a single organization (Wang et al., 2018).

As a distributed digital ledger technology, the blockchain technology works as a "peer to peer" distributed data infrastructure that can be used for recordkeeping and the transfer of value, with potential applications in multiple sectors including for supply chain management and logistics. In the agri-food supply chain, the blockchain technology shows promise for ensuring traceability and transparency of product information as fundamental differentiators (Kim et al. 2019).

This paper intends to explore the potential applications of blockchain-based technology to agri-food supply chains, its benefits and limitations. It also suggests possible approaches to overcome identified challenges.

The analysis is based on a literature review using the Scopus database and some other relevant sources. The literature review shows that while the relationship between blockchain technology and supply chains have been widely investigated (Treiblmaier, 2018), the research on the application of blockchain technology in agri-food supply chains is still at the embryonic stage. Therefore, it is worth exploring this under-investigated field.

## 2. Blockchain-Based Technology Applications in the Food Supply Chains

Food supply chains encompass agricultural upstream and downstream sectors from input supply to production, post-harvest handling, processing, transportation, marketing, distribution and retailing. So far, information on the origin, traceability and risks associated with the whole supply chain of agri-food products from production to consumer markets have been limited and difficult to check.

Early applications of blockchain technology in food supply chains are emerging.

For example, Carrefour allows consumers to scan the QR Code on a product's label – such as organic chickens and Sicilian oranges and lemons – to access information on their smartphone (https://actforfood.carrefour.com/our-initiatives/the-food-blockchain).

Barilla is using the blockchain technology to guarantee the origin and quality of Italian fresh basil for its pesto. Nestlé tracks the export flows of its chocalates (Baci

Perugina) to address risks of counterfeit products (Kerner, 2018). For the same purpose, the giant Alibaba has launched an initiative called "Food Trust Framework" which allows Chinese customers of Tmall Global (Alibaba-owned marketplace) to monitor shipments of food from Australia and New Zealand (Austrade, 2018).

The World Wildlife Fund (WWF) in Australia, Fiji and New Zealand, in partnership with high-tech, tuna fishing and processing companies, has launched a pilot project in the Pacific Islands tuna industry that will use blockchain technology to fight against illegal tuna fishing and to certify the origin of tuna through a QR Code (Visser & Hanich, 2018).

Walmart now traces over 25 products – such as fresh fruits, leafy greens, dairy, meat, poultry – from different suppliers using IBM Blockchain (Chang et al., 2019). Beyond tracking the origin of products, Walmart aims to address food safety issues by identifying the source of a foodborne disease outbreak, coordinate more effective recalls of foods thought to be contaminated and is considering storing additional data to foster sustainable practices in the supply chain (Smith, 2018).

## 3. Benefits of Blockchain Technology in Food Supply Chains

The blockchain technology has the potential to achieve significant supply chain improvements in critical performance measures.

In traditional food supply chains, available data on the production, process, transmission and sales of products is fragmented. The accessibility of information originally stored in supply chain participants' internal, centralized databases depends on further communication with other participants or on the creation of information-sharing systems managed by a third-party organisation (Montecchi et al., 2019).

Blockchain provides a shared information platform for all members in the supply chain that can facilitate the identification of the provenance, real-time location, and status of any food product at any step. By so doing, blockchain helps improve supply chain efficiency by enabling companies to develop informed supply and demand forecasting models and to gain full visibility into the supply chain.

Existing tracking systems are not always able to ascertain the origin of products, nor can guarantee the integrity and the transparency of information on food quality and safety. (Kim & Laskowski, 2018). By registering the initial purchase on a blockchain, the authenticity of the product can be permanently registered, and the ownership of the certificate can be transferred in a transaction that can be managed via smart contracts. By connecting the physical product with the blockchain through the use of an IoT device as a sensor, the connection between the product and the relative authentication certificate is guaranteed (Hughes et al., 2019). This level of transparency, reliability and visibility is useful to trace the origin of products and guarantee their authenticity, by binding the product with a unique ID of RFID tag. In addition, blockchain technology reduces risks of manipulation, as members of the supply chain are unable to tamper the information recorded in the system.

The use of biodegradable microsensors associated with smart contracts and related to the recording of events on blockchains has enormous potential. It could lead to the measurement of product temperature, humidity and other important quality factors. This is particularly important for fresh food to increase the safety and quality as well as shelf life of perishable products through real-time monitoring of transactional data, environmental conditions, inventory and quality standards along the supply chain (Sander et. al, 2018). Today the cost of these microsensors is very high, but in the future, their cost could be considerably reduced, thus allowing their use on a large scale and establishing the desired connection between food products and the IoT (Schlaefli, 2017).

By storing digitized records in a decentralized and immutable manner, blockchain can foster the adoption of a circular economy business model by tracking the quantity of food wasted and of food rescued throughout the whole food supply chain, leading to reduced product loss and increased margins.

Secure data-sharing between food chain participants enables better monitoring to improve food safety by eliminating the risk that supply chain members move fraudulent foods unknowingly. The full transparency of data also allows brands to quickly and proactively identify the source of contamination risks and manage potentially harmful food fraud without disrupting the entire supply chain.

A blockchain-based food supply chain can build trust amongst supply chain actors in the way products are produced, processed and distributed. Consumers increasingly seek assurances regarding the products they purchase beyond their provenance. Blockchain helps boost consumer confidence in the safety, quality and authenticity of the produce they are buying (Tse et al., 2018) by automatically digitizing and easily sharing audits, certificates, and other relevant records on sustainable practices.

## 4. Limitations of Blockchain Technology in Food Supply Chains

Blockchain is potentially disruptive technology for the design, organization, operations and general management of supply chains (Wang et al., 2019). Several obstacles exist to its widespread adoption (Hackius & Petersen, 2017). First, the deployment of blockchain technology requires significant changes in the way organizations execute routine operations. Members of the supply chain would be required to apply innovative methods for data recording, also forcing their integration with other technologies and tools such as WSN (Wireless Sensor Network), GPS (Global Positioning System) and GIS (Geographic Information System), sensor-RFID (Radio Frequency Identification) equipments, cloud computing services and smart contracts (Chang et al., 2019; Tian, 2016). The interoperability between blockchains and IoT devices still needs to be fully exploited.

The cost of emerging blockchain technologies together with their corollary equipment and necessary system upgrades is still high. For example, compared to traditional bar-codes, RFID tags are significantly more expensive, potentially limiting their application to improve traceability systems. The deployment of advanced technologies further requires the acquisition of technological competencies and knowledge skills. All these factors may hinder the widespread adoption of advanced technology systems in food supply chains, especially by small and medium enterprises and operators affected by the negative effects of the digital divide (Pepe, et al., 2013).

In a blockchain-based information-sharing platform, participants in the food supply chain have a shared responsibility for providing correct information regarding food products (Musso & Risso, 2012). It results that the system can only guarantee the authenticity of the information provided but not its truthfulness. An additional concern arises from the application of RFID tags or QR codes to product packaging which by itself does not necessarily guarantee that the product effectively corresponds to the label information.

Considering the current limited size of the individual blocks that can be appended to the blockchain, scalability of operations is emerging as an additional bottleneck, given the need to ensure the storage and synchronization of a growing amount of information to be recorded.

The governance of blockchain also goes with challenges related to the possibility of cryptographically recording commercial and production data in public open-source ledgers that no entity controls. Public ledgers struggle to achieve a global capacity given the difficulty to agree on protocol upgrades. Private ledgers run by a consortium of companies can create dependence on blockchain operators seeking to protect their market share and profits (Caese & Wong, 2017).

Regulatory uncertainty created by the current complex network of laws and codes in multiple jurisdictions, including on ownership, data protection and security, can hinder the use of this technology. Greater harmonisation of standards is needed to effectively regulate the automated, cross-border and denationalized nature of blockchains and smart contracts.

## 5. Final Considerations and Emerging Issues

In a globalised world with complex and fragmented food supply chains where food imports and exports are common practice, the digitalisation of the supply chain can achieve strategic improvements for agri-food companies. Blockchain technology and corollary equipment can enable access to information, real-time monitoring of the activities and traceability of food products by all members of the supply chain (Sander et al., 2018). It can ensure reliability, authenticity and accuracy of information on food product safety, quality and sustainability through cross-border traceability, information-sharing and enhanced transparency systems.

Companies in the supply chain can communicate in a transparent manner the origin and quality of their food products to consumers and regulators, including raising awareness about sustainability opportunities and practices at each step of the supply chain. This create differentiation opportunities, leading to enhanced brand equity, reputation, and trustful relationships with consumers.

Despite the undeniable benefits of blockchain and the potential to achieve significant improvements to enhance transparency, reliability and accuracy of information in food supply chains, considerable challenges to its widespread adoption persist. These challenges include regulatory uncertainty, lack of harmonised standards and protocols, privacy issues, cost and knowledge barriers. In order to unleash the transformational potential of blockchain technology in food supply chains, the centralised governance systems of existing information sharing platforms and supply chain management should also be re-designed (Saberi et al., 2019), with the integration of blockchain and IoT devices.

Notwithstanding, the tamperproof record it creates, blockchain technology cannot yet guarantee the truthfulness of the recorded information and it is heavily reliant on the provision of correct and accurate data by supply chain participants.

It is necessary to develop strategies to help companies overcome these challenges and fully exploit the advantages of the blockchain technology (Min, 2019).

In order to reduce costs, address risks and foster efficiency and sustainability performance, participation of supply chain members in industry-wide collaborative efforts would be highly desirable. Horizontal collaboration can maximise benefits and assist members with the development of the required technological infrastructure and the building of the necessary financial, managerial and technical skills that otherwise would not be individually achieved by members in the supply chain.

In this respect, the creation of a pre-competitive space to identify innovative solutions could facilitate the mutaul understanding of the challenges associated to a new operating environment, while offering at the same time the opportunity to explore innovative solutions to commonly identified issues.

## Bibliography

Accorsi, R., Cholette, S., Manzini, R., & Tufano, A. (2018). A Hierarchical Data Architecture for Sustainable Food Supply Chain Management and Planning, *Journal of Cleaner Production*, (203), 1039-1054.

http://doi.org/10.1016/j.jclepro.2018.08.275

Austrade, & the Australian Food and Grocery Council (2018). *Exporting Food and Beverage to China: A Guide for Australian Business*, Australia.

Bosona, T., & Gebresenbet, G. (2013). Food Traceability as an Integral Part of Logistics Management in Food and Agricultural Supply Chain, *Food Control*, (33), 32-48. http://doi.org/10.1016/j.foodcont.2013.02.004

Brondoni, S. M. (2003) Network Culture, Performance & Corporate Responsibility. *Symphonya Emerging issues in Management (symphonya.unimib.it*, (1).

http://dx.doi.org/10.4468/2003.1.02

Brondoni, S. M. (2018). *Competitive Business Management and Global Competition. An Introduction*, in Brondoni, S. M. (ed.), *Competitive Business Management. A Global Perspective*. New York & Turin: Routledge & Giappichelli.

Brondoni, S. M., & Pepe, C. (2007). Overture de Ethics in Global Supply Chains. *Symphonya Emerging issues in Management (symphonya.unimib.it)*, (1).

http://dx.doi.org/10.4468/2007.2.01ouverture

Casey, M. J., & Wong, P. (2017). Global Supply Chains Are About to Get Better, Thanks to Blockchain, *Harvard Business Review Digital Articles*, (1) 2-13.

http://hbr.org/2017/03/global-supply-chains-are-about-to-get-better-thanks-to-blockchain

Casado-Vara, R., Prieto, J., De la Prieta, F., & Corchado, J.M. (2018). *How Blockchain Improves the Supply Chain. Case Study Alimentary Supply Chain*, Procedia Computer Science (134) 393-398. http://doi.org/10.1016/j.procs.2018.07.193

Chang, S.E., Chen, Y.C., & Lu, M.F. (2019). Supply Chain Re-Engineering Using Blockchain Technology: A Case of Smart Contract Based Tracking Process, *Technological Forecasting & Social Change*, (144) 1-11.

http://doi.org/10.1016/j.techfore.2019.03.015

Civera, C., & Freeman, R.E. (2019). Stakeholder Relationships and Responsibilities: A New Perspective. *Symphonya. Emerging Issues in Management (symphonya.unicusano.it)*, (1), 40-58.

http://dx.doi.org/10.4468/2019.1.04civera.freeman

Di Carlo E., Testarmata S. & Fortuna F. (2015). Boundaries of the Business Model within Business Groups, *Journal of Management and Governance* (20)1-42

http://doi.org/10.1007/s10997-015-9338-9

Dujak, D., & Sajter, D. (2018). Blockchain Applications in Supply Chain, *SMART Supply Network*, 21-24.

http://doi.org/10.1007/978-3-319-91668-2_2

Engelseth, P. (2009). Food Product Traceability and Supply Network Integration. *Journal of Business and Industrial Marketing*, 24 (5), 421-430.

http://doi.org/10.1108/08858620910966291

European Food Safety Authority (2019). Annual Report of the EFSA Scientific Network of Risk Assessment of Nanotechnologies in Food and Feed for 2018, available at https://www.efsa.europa.eu/it/supporting/pub/en-1626.

Firica, O. (2017). Blockchain Technology: Promises and Realities of the year 2017, *Quality – Acces to Success*, (18), 51-58.

Galvez, J.F., Mejuto, J.C., & Simal-Gandara, G. (2018). Future Challenges on the Use for Food Traceability Analysis. *Trends in Analytical Chemistry*, (107), 222-232. http://doi.org/10.1016/j.trac.2018.08.011

Hackius N., & Petersen M. (2017). Blockchain in Logistics and Supply Chain: Trick or Treat?, in Kersten W., Blecker T. & Ringle C. M. (Eds.), Digitalization in Supply Chain Management and Logistics, epubli.

http://doi.org/10.15480%2F882.1444

Hughes, A., Park, A., Kietzman, J., & Brown, C. (2019). Beyond Bitcoin: What Blockchain and Distributed Ledger Technologies Mean for Firms. *Business Horizons*, (62), 273-281. http://doi.org/10.1016/j.bushor.2019.01.002

Kerner M., (2018), Simplifying Blockchain App Development with Azure Blockchain Workbench, Microsotf Azure, available at http://azure.microsoft.com/it-it/blog/simplifying-blockchain-app-development-with-azure-blockchain-workbench-2/

Kim, H.M., & Laskowski, M. (2018). Toward an Ontology-Driven Blockchain Design for Supply-Chain Provenance. *Intelligent Systems in Accounting, Finance and Management*, 25 (1), 18-27. http://doi.org/10.1002/isaf.1424

Min, H. (2019). Blockchain Technology for Enhancing Supply Chain Resilience. *Business Horizons*, 62 (1), 35-45.

http://doi.org/10.1016/j.bushor.2018.08.012

Montecchi, M., Plangger, K., & Etter, M. (2019). It's Real, Trust Me! Establishing Supply Chain Provenance Using Blockchain. *Business Horizons*, 62 (3), 283-293.

http://doi.org/10.1016/j.bushor.2019.01.008

Musso, F., & Risso, M. (2012). ICT Innovation for Buyer-Seller Relationships in International Supply Chains, in Indian Institute of Science, Bangalore. Department of Management Studies, Driving the Economy through Innovation and Entrepreneurship. Emerging Agenda for Technology Management. Bangalore: Springer India.

http://doi.org/10.1007/978-81-322-0746-7_54

Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. Available at http://bitcoin.org/bitcoin.pdf.

O'Leary, D.E. (2017). Configuring Blockchain Architectures for Transaction Information in Blockchain Consortiums: The Case of Accounting and Supply Chain Systems. *Intelligent Systems in Accounting, Finance and Management*, 24 (4), 138-147.

http://doi.org/10.1002/isaf.1417

Pepe, C. (2007). Corporate Values in Global Supply Chains. *Symphonya Emerging issues in Management (symphonya.unimib.it)*, (2), 5-11.

http://dx.doi.org/10.4468/2007.2.02pepe

Pepe, C., Musso F., & Risso M. (2010). SME Food Suppliers Versus Large Retailers: Perspectives in the International Supply Chains. DSI Essays Series, (13), Milano, McGrawHill.

Poniman, D., Purchase, S., & Sneddon J. (2015). Traceability Systems in the Western Australia Halal Food Supply Chain. *Asia Pacific Journal of Marketing and Logistics*, 27 (2), 324-348. http://doi.org/10.1108/APJML-05-2014-0082

Risso, M. (2012). A Horizontal Approach to Implementing Corporate Social Responsibility in International Supply Chains. *International Journal of Technology Management*, 58(1-2), 64-82.

http://dx.doi.org/10.1504/IJTM.2012.045789

Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain Technology and its Relationships to Sustainable Supply Chain Management. *International Journal of Production Research*, 57 (7), 2117-2135.

http://doi.org/10.1080/00207543.2018.1533261

Sander, F., Semeijn, J., & Mahr, D. (2018). The Acceptance of Blockchain Technology in Meat Traceability and Transparency. *British Food Journal*, 120 (9), 2066-2079. http://doi.org/10.1108/BFJ-07-2017-0365

Schlaefli, S. (2017). *Biodegradable Microsensors for Food Monitoring*, available at: https://phys.org/news/2017-09-biodegradable-microsensors-food.html.

Smith M. (2018). In Wake of Romaine E. coli Scare, Walmart Deploys Blockchain to Track Leafy Greens, *Walmart Communications*, available at https://corporate.walmart.com/

Soon, J.M., Chandia, M., & Regenstein, J.M. (2017). Halal Integrity in the Food Supply Chain. *British Food Journal*, 119 (1), 39-51.

https://doi.org/10.1108/BFJ-04-2016-0150

Tan, B., Yan, J., Chen, S., & Liu, X. (2018). The Impact of Blockchain on Food Supply Chain: The Case of Walmart. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), (11373), 167-177.

Tian F. (2016), An Agri-food Supply Chain Traceability System for China Based on RFID & Blockchain Technology," *13th International Conference on Service Systems and Service Management (ICSSSM)*, Kunming, pp. 1-6.

http://doi.org/10.1109/ICSSSM.2016.7538424

Tian, F. (2017). A Supply Chain Traceability System for Food Safety Based on HACCP, Blockchain & Internet of Things. *14th international Conference on Services Systems and Services Management*, ICSSSM 2017 - Proceedings, art. no.7996119.

http://doi.org/10.1109/ICSSSM.2017.7996119

Treiblmaier, H. (2018). The Impact of the Blockchain on the Supply Chain: A Theory-Based Research Framework and a Call for Action. *Supply Chain Management*, 23 (6), 545-559. http://doi.org/10.1108/SCM-01-2018-0029

Tse, D., Zhang, B., Yang, Y., Cheng, C., & Mu, H. (2018). Blockchain Application in Food Supply Information Security. *IEEE International Conference on Industrial Engineering an Engineering Management*, 2017-December, 1357-1361.

http://doi.org/10.1109/IEEM.2017.8290114

Visser C., & Hanich Q. (2018). How Blockchain is Strengthening Tuna Traceability to Combat Illegal Fishing, 22 January, TheConversation 1-4.

Wang, X., Li, D., & O'Brien C. (2009). Optimisation of Traceability and Operations Planning: An Integrated Model for Perishable Food Production. *International Journal of Production Research*, 47(11), 2865-2886.

http://doi.org/10.1080/00207540701725075

Wang, Y., Hugh Han, F., & Beynon-Davies, P. (2019). Understanding Blockchain Technology for Future Supply Chains: A Systematic Literature Review and Research Agenda. *Supply Chain Management: An International Journal*, 24(1), 62-84.

http://doi.org/10.1108/SCM-03-2018-0148

Wang, Y., Singgih, M., Wang, J., & Rit, M. (2019). Making Sense of Blockchain Technology: How Will it Transform Supply Chains? *International Journal of Production Economics*, (211), 221-236.

http://doi.org/10.1016/j.ijpe.2019.02.002