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The use of blockchain technology to improve the food supply chain

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Abstract

The purpose of the article is to show how to use relatively new and very innovative Blockchain technology to improve the food supply chain. In countries such as the United States or Thailand is starting to be an indispensable element in the agri-food sector. At the outset, it should be said what the Blockchain technology is, the use of which is becoming very broad in many sectors of the economy, including in the area of monetary policy of the state. It is used when creating virtual money, i.e. cryptocurrencies, which, despite the controversy they arouse, as well as the world of virtual finance in the COVID-19 era, begin to play a significant role. Blockchain (BCT) in the case of the food supply chain, despite the fact that it is a relatively new digital technology, may revolutionize its functioning. This technology is designed to provide the possibility of storing information in a database of transactions and products, which is decentralized and distributed and not susceptible to changes and manipulations. BCT believes it can play a positive role in ensuring food safety and quality. The main benefit of using this technology is the increased transparency of food supply chains. BCT makes it possible to increase the efficiency of tracking systems and identification of agri-food products in the supply chain. This means that thanks to BTC, it is possible to reduce the number of cases of food adulteration and the unauthorized use of food quality certificates. Nevertheless, BCT, due to the fact that it is a new technology, is not fully developed, i.e. the possibility of scaling BCT may turn out to be ineffective in more extensive and complex supply chains including multi-component products. In addition, it should be remembered that this technology is associated with barriers of a social, economic, legal and financial nature, which may adversely affect the further use of BCT in food supply chains. Despite the growing interest of agri-food sector enterprises in using BCT, its implementation in food supply chains may progress slowly.

Keywords

Blockchain technology, agri-food sector, food supply chains, digital technology, agri-food enterprises

Presenters Profile

Professor Krzysztof Marecki and Dr Agnieszka Wójcik -Czerniawska are employees of the Warsaw School of Economics. As employees of the Department of Economics and Finance of Local Government, they deal with the issues of sustainable development in a very broad sense. In the area of their research interests there is both sustainable development in the field of renewable energy and issues in the area of finances, including finance technology, in which innovative financial tools such as Blockchain are related both to finances in the strict sense, i.e. cryptocurrencies and in the broad sense, i.e. to influence a number of economy sectors, i.e. agriculture, industry, services.

Introduction

New digital technologies are changing now the conditions for the functioning and competition of business entities in various industries and sectors of the global economy from the financial sector, through the processing industry and trade. The agri-food sector also increasingly uses the opportunities offered by the digital revolution. One of the digital technologies with a particularly high potential for the agri-food sector in the context of ensuring food safety and quality is Blockchain technology. This technology emerged at the end of the last decade in the wake of the global financial crisis in 2008 and 2009 as a response to a drastic decline in confidence in institutions involved in the regulation and supervision of financial markets. The main driving force behind the development of the Blockchain was the idea of bitcoin - a cryptocurrency functioning only on the Internet outside the control of the government and financial institutions [Klinger B., Szczepański 2017, p. 11-27]. Such an assumption cryptocurrency is breaking the paradigm of the central bank, which assumes that the issuance of money can only take place on the basis of centralized mechanisms, i.e. the only issuer of money may be the central bank. On the other hand, the idea of cryptocurrencies is based on Blockchain technology to create them in a distributed mechanism. The principles of operation of the new internet currency are described in the article "Bitcoin: A Peer-to-Peer electronic cash system", which was published in 2008 by a person or a group of people (no one know) using the pseudonym Satoshi Nakamoto [Nakamato S. 2018]. The proposed version of electronic payments was to enable online payments to be made directly between system users, without the need to register transactions by third parties. Shortly after the article was published, in January 2009, an open source program appeared on the Internet that generated the first 50 bitcoin block referred to as: genesis block. However, BCT is not only a technology that is limited to cryptocurrencies [Klinger B., Szczepański 2017, p. 11-27]. Thanks to a decentralized network of tens of thousands of computers, proof of work and trusted mechanisms of distributed transaction verification across these computers, Blockchain provides a secure structure for the storage and use of information and data. Blockchain can therefore be used to streamline any processes and activities that require information and data management. The technology can also improve the functioning of food supply chains, especially in areas related to agri-food traceability, origin, safety and quality [Smit H. 2017]. The first experiences and pilot projects show that the BCT has a significant potential to increase the transparency of the functioning of food chains [Ge L. 2017]. On the one hand, it can provide a reliable and tamper-resistant and forgery-resistant information path about the origin of products and food quality certificates, on the other hand, it can guarantee that the entities involved have an unchanged record of all completed transactions [Kasior K. 2018, p.19]. These benefits more and more often convince agri-food companies and companies from the advanced technology industry to implement joint, innovative projects on the basis of BCT [Galvin D. 2017].

Methods

This study uses materials from both English and Polish publications. The choice of such popular science publications in these languages is due to the fact that it is in the area of these countries, i.e. highly developed countries, that the issue of Blockchain technology, bitcoin and cryptocurrencies is more and more often discussed. In the case of compact materials, articles and publications from universities that deal with the broadly understood issues of it but examples from business practice will also be presented- USA, Thailand. The use of blockchain technology in these two countries is dictated by several variables. The United States of

America was chosen as an example for being the dominant world economy that largely sets global trends. Blockchain technology and the entire mechanism of activities in the area of IT or Fin-Tech, which blockchain technology approaches due to the best developed computerization in this country (Silicon Valley, IBM, Microsoft) seem to be the right choice. It is also worth emphasizing that the USA is a huge production market, but also a market for a number of products, including agri-food. The United States is the largest food producer in the world. The second selected country, Thailand, was chosen both because about 40% of the working population work in agriculture, growing rice, maize and sugar cane. Thailand exports mainly to Europe and North America: rice, tin and electrical equipment. On the other hand, unemployment in Thailand is around 1%, while the social inequality rate is one of the highest in the world: 53.6. Therefore, such an obvious counterweight to the USA and Thailand seems to be a perfect example of how technology is used in all developmentally different countries.

BCT applications in food supply chains

Blockchain technology can be used in various areas and fields, both related and unrelated to the world of finance [Creasey S. 2018]. The OECD [OECD 2018] divides the potential applications of Blockchain technology into three main categories:

1) Financial transactions - BCT can be unpermisssioned here, as in the case of Bitcoin, which provides everyone with the opportunity to participate in the chain, or permissioned nature, where only selected entities are entitled to register and check data in the book;
2) Logging and verification systems - in this category, Blockchain acts as a tool for creating reliable and unchangeable data and information records. You can indicate, among others on registers enabling the confirmation of property rights (e.g. to real estate), checking the origin and authenticity of specific items and goods, or verifying the authenticity of clinical trial results;
3) Smart contracts - BCT also allows you to attach additional data to transactions involving the exchange of funds or any other digital assets. The data added to the transaction are in fact computer programs that specify what conditions must be met for the transfer to be made. If the terms of the contract are met, the transfer is carried out automatically. Smart contracts therefore, they reduce transaction costs related to the involvement of third parties and legal service of transactions. They also increase the transparency of contract execution and minimize the time needed to complete the transaction.

The indicated properties of BCT make it a technology that can significantly facilitate and improve the functioning of supply chains of products and services to end recipient. In the agri-food sector, the use of BCT seems particularly possible and advisable. Blockchain solutions and applications take into account most of the problems and needs that arise in managing the flow of agri-food products between the individual links of the chain. These chains are now extremely elaborate and complex. They contributed to this, among others liberalization of world trade, increasing competition between enterprises in the agri-food sector as well as product and process innovations. Not only has the number of entities involved in the production, distribution and sale of food increased (thanks to the development of e-commerce), but also the number of food products offered. The extremely extensive and rich food offer for most consumers in the world currently includes simple and unprocessed products, multi-ingredient and highly processed products, conventional and unconventional products (e.g. genetically modified), ecological, meeting specific health requirements

(functional food, superfood), and also having specific storage and distribution requirements [Kasior K. 2018].

The use of Blockchain in the food supply chain can already be observed both in Thailand and in the USA. In March 2019, Deputy Minister of Agriculture and Agribusiness announced that Thailand would apply Blockchain technology to food and agricultural supply chains to track down producers. At the time, they stated that the system is defined by using Blockchain technology and its application in the agricultural sector, where "consumers and authorities can track the origin of producers from their laboratories and farms, and their delivery to the factory, suppliers and users" [Thailand Ministry of Finance 2019].

The US Department of Agriculture has proposed to amend the rules on organic products. The purpose of these activities is to implement Blockchain technology to support the supply chain. On August 5, 2020, the U.S. Department of Agriculture (USDA) submitted its report. In it, he noted that they are making every effort to ensure that electronic systems such as (BCT) can be used in tracking the supply chain of organic products. “BCT can provide secure, verifiable, transparent and near-instantaneous traceability of supply chains. BCT can also protect confidential business information and trade secrets by automatically restricting data only to authorized entities. "Distributed ledger technology is a distributed database technology whose registers are replicated, shared and synchronized within the consensus of various geographically dispersed individuals, companies or institutions. It is predicted that future use of BCT may improve the flow of processes that use databases. We will have to wait for the use of the BCT. However, the agency acknowledged that the use of a new technology such as BCT would require additional time. The project must be fully completed and tested before it can be implemented in the organic food industry. “Unfortunately, there are several barriers that are slowing down the process of widespread adoption of the new technology. These include limited access to technology and connectivity in urban areas, widespread adoption of new electronic standards and high project costs ”. Growing consumer interest in healthy cuisine is revolutionizing the organic food industry. The need to improve the supply chain has never been seen before. Today, the fast-growing market boasts health-conscious consumers and a fast-growing market of retailers, broadcasters and distributors. Examples of using the supply chain. The report lists several corporations that rely on Blockchain-based solutions. The list includes Walmart, which uses a system to identify mango and pork in the supply chain, Nestle tests the Blockchain to improve its milk supply chain, and Bumble Bee Foods monitors the supply chain of yellowfin tuna from Indonesia.

It is worth noting that in the case of food, the frequent problem is contamination and contamination of food in many countries and regions, and they prove the limited effectiveness of the current system. An example is the infection of consumers with the STEC strain of E. coli in 2015, associated with the consumption of food in the premises of Chipotle Mexican Grill restaurants in the USA, which poisoned 55 customers [Kshetri N. 2018]. This event led to a sharp decrease in sales in this restaurant chain and a deep reduction in the value of the company's shares (by 42%). In part, the problem was caused by the heavy dependence of Chipotle and its related food purchasing companies on an extensive and less transparent supplier network [Kshetri N. 2018]. In some countries, unfair practices, including deliberate food adulteration, remain the primary cause of food incidents, and to a lesser extent human-independent equipment failure, technical accidents, pathogenic or pathogenic microorganisms present in food [Galvin D. 2017]. These problems are illustrated by the case of China, where from 2001 to 2013 there were over 49,500 incidents, the vast majority (68%)

of which resulted from the unethical behaviour of entities involved in the production, distribution or sale of food [Galvin D. 2017]. The costs of unfair practices are borne to a varying extent by actors in the food supply chain. Unfair practices also contribute to wider social losses in the economy. Blockchain, thanks to the function of creating unchanging records of events and processes, can provide greater transparency in supply chains and thus reduce the problem of unfair business practices. Blockchain technology could improve food tracking and identification systems in two ways. The first is to monitor the overall quantity of food in the supply chain (by controlling sales and purchase volumes), and the second is to track the path of individual agri-food products in the supply chain [Kairo 2017]. It is currently difficult to control the volume of sales and purchases of individual crops, such as beans, cocoa, coffee and many other raw materials. Recording all purchases and sales of agricultural products within the BCT would solve this problem and at the same time provide tools to monitor the actual composition of selected products. BCT would allow for quick and easy identification of false data on the quantity of a given commodity. As an example, illustrating the benefits of using BCT, there are transactions involving basmati rice - under the BCT, the volume of basmati rice sold cannot exceed the volume of basmati rice purchased by parties involved in the supply chain. Practitioners indicate that by controlling the overall volumes of agricultural products on the market, BCT would eliminate situations where an entity buys plain rice, mixes it with a small portion of basmati rice and then sells the entire batch as Basmati rice at a higher price. Such cases could be easily identified as the amount of basmati rice tracked by BCT and entering the supply chain cannot be greater than the amount that leaves the chain [Kairo 2017].

The second way to integrate BCT into food tracking, monitoring and traceability systems is technically and organisationally more complicated. Requires integration of supply chain transaction recording systems with data recorded on products using barcodes or QR codes, as well as data from Radio-frequency identification (RFID)[2] systems and other sensors placed on food facilities and packaging or other containers in which food is stored and transported [Tian F. 2017]. RFID technology has been used in the agri-food sector for a long time (including in the EU under the obligation to identify and register animals), but its capabilities are still not fully used in food safety and quality assurance systems. The tags and labels identifying given products or objects by means of radio waves can record data on events and processes within the entire agri-food chain - from the production stage (e.g. information on the variety of a given plant, place and time of sowing, methods and types of fertilization , while in the case of animals, among others, on the methods of feeding, drugs used, past diseases), at the processing stage (information on the type of product, amount and type of ingredients and additives used, weight, expiry date), at the distribution stage (information on the methods and conditions of storage and transport) and at the stage of sale (e.g. using information about the use-by date to monitor the product offer on store shelves / replace products on shelves) [Tian F. 2016]. Placing information from RFID tags in a counterfeit-resistant Blockchain, and ultimately also creating a cooperation platform between BCT and the Internet of Things, enabling communication between various sensors and sensors in real time, could significantly increase the effectiveness of the food safety and quality assurance system, especially within

[2] A technology whereby digital data encoded in RFID tags or smart labels (defined below) are captured by a reader via radio waves. RFID is similar to barcoding in that data from a tag or label are captured by a device that stores the data in a database. RFID, however, has several advantages over systems that use barcode asset tracking software. The most notable is that RFID tag data can be read outside the line-of-sight, whereas barcodes must be aligned with an optical scanner- http://www.abr.com

the framework of more extensive and complex supply chains. The main benefit of such a system would be not only to accurately identify the location of spoiled or contaminated food products or food batches that are hazardous to consumer health, but also to respond to hazards as they arise (thus potentially preventing specific food incidents and crises). At the same time, more advanced analytics of data collected within the BCT and the Internet of Things could, based on predictive algorithms, enable prediction of specific threats and incidents before they occur [Kasior K. 2018]. The use of Blockchain technology may also eliminate or significantly reduce the problem of fraud and falsification of food quality certificates [Ge L. 2017]. The emergence of organic food and food that meets the specific requirements and expectations of consumers has made the number of certifying institutions and the number of food quality certificates significantly increase in the recent period. Increasingly, certificates are used by food producers as an element of a marketing strategy (e.g. they build a brand image and potentially improve sales, the company's commitment to achieving sustainable development and environmental protection goals). Food products with a quality certificate are usually more expensive than their counterparts without similar certificates. However, their presence on the product is not always a guarantee of quality - cases of misuse of certificates with regard to products that do not meet the requirements specified by the certifying authority are not uncommon. Registering certificates in the Blockchain would allow for quick and easy verification of the authenticity and validity of certificates assigned to specific products and manufacturers. Certifying bodies after granting rights certificates could also authorize selected entities-organic farms to issue certificates on their behalf [Ge L. 2017]. As a result, BCT could limit the cases of unauthorized use of certificates, reduce transaction costs of the certification process (e.g. through the use of smart contracts) and reduce the administrative burden on certifying authorities. Greater transparency and credibility of the certificates could, at the same time, translate into their greater market value. In addition to the use of BCT to identify weak links in the food supply chain and to manage food quality certificates, the possible applications of BCT to create data repositories on the properties of agri-food products, production conditions, and environmental and socio-economic aspects of the functioning of agri-food chains should be indicated. The sources of this data in the Blockchain can be the previously indicated RFID tags.

Currently, many consumers, especially in developed countries, have very high expectations and requirements with regard to both nutritional information and information on the impact of agricultural production on the natural environment and living conditions of local communities. At the same time, consumers are increasingly looking for information on the products of interest to them and their properties not on paper packaging and labels of food products, but on the Internet and using special applications supported on mobile devices. This information is often unverified. Including an information pack on food products and their properties in the Blockchain would increase the quality and certainty of nutritional information for consumers. In the same way, information could be provided to consumers about the conditions of production and the terms of cooperation between the various links in the supply chain. Thanks to transactions recorded in the Blockchain, the consumer could quickly check whether the goods in his basket were produced in accordance with the principles of sustainable development and whether the farmer, who is most often the weakest link in the supply chain, was paid for it. In the long term, the use of BCT in the agri-food sector could therefore not only facilitate purchases, but also lead to more informed consumer choices and ultimately to more socially and environmentally sustainable food supply chains. [Kasior K. 2018].

Results

In summary, there are three potential application areas for Blockchain technology in food supply chains. These are: food tracking and identification systems; management of the certification process, including verification of the authenticity of food quality certificates; data repositories on agri-food products, production conditions and conditions of cooperation between the different links in the food supply chain, including monitoring of fair prices for farmers. The indicated activities taken together meet the growing needs in terms of ensuring broadly understood integrity in food supply chains [Hoorfar J. 2011]. According to this concept, activities for food safety and quality cannot be limited to technological and organizational aspects of food production and distribution, but should also take into account economic, social and environmental aspects related to the functioning of agri-food chains [Hoorfar J. 2011]. Blockchain, providing tools both for monitoring the flow of food products and their identification, as well as for recording other processes and events in the food supply chain, would allow a holistic approach to food safety and quality management. A significant problem in the context of the prospects for using BCT to ensure food safety and quality remains the extremely complex and varied regulations between countries and requirements for food products, and at the same time the lack of a common, international legal framework defining the conditions and principles of the digital economy. A barrier to the implementation of BCT in the food safety and quality management processes may be resources and financial means insufficient to undertake the required investments. It may be costly and time-consuming not only to transfer data and information from currently operating IT systems to the Blockchain, but also and above all to combine BCT with other technologies (including RFID) due to the still very high cost of labels based on this technology [Tian F. 2016]. The problem may also be large differences between individual countries and regions in terms of the possessed socio-economic and IT infrastructure. Today's food supply chains span many different countries, with varying levels of economic development and investment opportunities. The implementation of BCT within this type of chain can therefore be a big challenge. The main benefits and opportunities of managing food supply chains with the use of BCT include: greater credibility, transparency and certainty of information on agri-food products present in the food supply chain, reduction of costs related to the management of food incidents requiring the withdrawal from the market of the contested products, savings resulting from the reduction of food fraud and food quality certification, reduction of transaction costs due to the lack of necessity to involve intermediary institutions in tasks and processes related to ensuring food safety and quality [Kasior K. 2018].

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