The Impact of Blockchain Technologies for the Agriculture Development and Sustainability

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Abstract

Global warming has changed our environment and our society at a high speed. Luckily for us, scientists and researchers have worked around the clock on technologies that could ease the effects of the principal sectors of the economy – agriculture and manufacturing. Although, in the last two to three decades, services have been on a continuous evolutionary pattern, and, more or less, have attracted the spotlight, the fundamentalism of the first two sectors of the economy continues to daunt on our society, and, particularly, on the management and technologies behind it. The current paper addresses the necessity of breaking the existing business model in agriculture, and describes the architecture behind a new model that pertains to the innovative data-sharing capabilities of the blockchain for the ultimate purpose of agricultural development and sustainability. The study was designed around a content analysis on previous research, and added on the alignment to the new potential business model for smart agriculture using blockchain technologies.

Keywords

Blockchain technologies, e-agriculture, knowledge economy, machine learning, food safety, agriculture insurance.
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Introduction

Agriculture represents the first sector of the global economy, and the first catalyst of the human species evolution, now, part of a globalized food supply. The time came for the global civilization to acknowledge the cumulative negative impact of different anthropic factors on the environment and the society at large. Global warming has been one of the most debated subjects, especially since it has destabilized the entire global agricultural system. With a growing world population, food shortages are not an option. The technological wave has presented multiple solutions, with positive impact on the agricultural sector too. The current paper starts with a content analysis of the most recent studies in the field, in order to underline the main commitments that have been made within the industry in relation to the application of blockchain technologies (Nofer, et al., 2017; Zheng, et al., 2018; Wüst and Gervais, 2018; Abadi and Brunnermeier, 2018), and to project on the business model (Grigorescu, et al., 2020) furthering the management approach relevant for the 21st century agribusiness.

Review of Scientific Literature

Agribusiness (Zylbersztajn, 2017) is a concept known as the combined collection of manufactured and distributed agricultural supplies, various production operations within the sector, and the logistics involved with the agricultural commodities. Its underlying meaning refers to the widely acknowledged

perspective of an interdependent and interconnected agriculture sector formed around various economic agents, that create value-added in the economy, with the acceptance of an intrinsic downfall through time and consistent strategic consequences (Iordan, et al., 2015). The 1960s marked the moment when the small farmer faced the large corporate farm, showcasing, at a global level, the true dimensions of the economic system, and its implications for the agriculture sector. From this point on, agriculture and all its implied activities and organizations had to be interpreted through the lens of globalization, digital transformation, asymmetric information, property rights, public policy, opportunism, strategic management. Nevertheless, it was clear that, although, certain borders were crossed into a different dimension, the world continued to rely on motions specific to the past (James, 2005). Today, the dominant view is that technology has a huge potential for relevance, knowledge, expansion, and enriched mechanisms (Foresman, 2007; Rodriguez, et al., 2015), providing a new opportunity to the helix of economic agents, institutional and governance agents, as well as scholars to make the most out of the global chains, networks and coordinated standards for the overall growth and evolution of the agricultural sector, and for its output in the world economy.

Nowadays, technology is the safest solution to any specific problem, and most of the economic sectors are heavily relying on the support and applications of different types of technologies. At the boundary between digitalization and digital transformation lies the blockchain technologies and applications (Risius and Spohrer, 2017). A blockchain technology refers to a decentralized structure that records the origin of digital assets in real-time, and the whole process is transparent. This new technology is considered to reduce risks and/or fraud, and has potential for business scalability. When looking over all those aspects, not only the services sector will become highly reliant on the blockchain technology and its applications, but also the other two economic sectors – manufacturing and agriculture (Yadav and Singh, 2019).

Agriculture started a reactionary process, and, today, it evolves further toward chains, networks, and technology. Blockchain technologies have the capacity to trace all the information transitioning the food supply chain in a secure and cost-controlled manner. Furthermore, it enhances the opportunities of innovation-driven prospects, including smart farming and smart agriculture insurance (Ge, et al., 2017).

Research methodology

The current research is based around a content analysis of the latest studies performed in the field of agriculture, and blockchain technologies and applications, by unitizing their context regarding specifics of the blockchain technologies attributed or tested in the agriculture sector. The units of analysis are further coded in order to give a particular situational interpretation to each of the former. The sampling of the scientific articles was made manually, by selecting 20 papers that have been written in the last year (2020-2021), in the order of their search relevance on Google Scholar via the keyword *blockchain technologies in agriculture*. The units of analysis and their attributed code are divided across categories reflecting different elements of the blockchain technologies and of smart agriculture practices. Eventually, all the results are interpreted based on the potential business model for the new dawn of agricultural sector.

Results of content analysis

The preliminary part of the research has been constructed around the selection of the scientific papers that would further be analyzed for their content related to the topic of blockchain technologies and application in the agriculture sector. Table no. 1 contains the paper' identification DOI number, the coding and recording units. The content analysis showcased different types of blockchain technology applications, mostly in simulated environments, given the fact that the learning curve for the implementation of such technologies and strategies, as well as the cost inputs still represent a sensible dimension.

Table no. 1. Selected scientific papers and content analysis

Research paper (DOI)	Code	Recording units
10.1016/j.compag.2020.105251	A1-A12	user profile; environmental data sensors; control parameters/IoT data; legacy farm system; time-series data; optimal conditions strategies; optimized settings/Smart contract; transaction history/Device monitoring; network-level commands/digital certificates/cryptographical pair: public-private key/agriculture data/KPIs/water level optimal operation/complex application/authentication strategies/scalability, accountability and security
10.3390/app10124113	B1-B4	Low level stakeholder tech knowledge; large geographical area; deployment obstacles/no guarantee data accuracy; monitoring difficulties/conceptual designs/transparency and trust; enormous energy and financial cost
10.3389/fbloc.2020.00007	C1-C8	Index insurance; automated, timely payments; machinery data; risk reduction/transparency/smart farm model/benefits to large farms/recording traceability/motivation for precise information/costly/infrastructure time-consuming
10.1016/j.ijinfomgt.2019.05.023	D1-D5	Nascent stage/positive impact/decentralized, shared DB/technical and regulatory challenges/ease the certification norms
10.1016/j.jclepro.2020.122503	E1-E3	High convenience/modernization/e-agriculture
10.1016/j.jclepro.2020.122071	F1-F2	Intelligent device nodes; GPS monitoring/fork issues
10.1109/ACCESS.2020.2973178	G1-G8	Precision agriculture/trading system/pressure calculations/open-access solution; unauthorized access/impersonation attacks/password breach/IDS for security/shield against environmental factors
10.1016/j.compag.2020.105476	H1-H5	Transparency; scalability/reduction of loses and costs; traceability/trade rates; cryptocurrency/global trade/high energy consumption; blockchain forking
10.1109/ACCESS.2020.2986257	I1-I4	Traceability, accountability/credibility/cryprocurrency/challenges for practical implementation
10.4018/IJAEC.2020100102	J1-J5	Smart agriculture; digital identity/crisis control/AI/IoT devices/efficiency of SCM
10.1016/j.jclepro.2020.124496	K1	Blockchain-enabled relay-aided wireless network for sustainable e-agriculture
10.14569/IJACSA.2020.0110457	L1-L5	P2P network; cyber law/farm clustering/simulation; network stability/cost reduction/sense environmental characteristics
10.1016/j.resconrec.2020.104877	M1-M3	No regulation/high energy/country context influence
10.1109/OJCS.2021.3053032	N1-N2	Consumer pressure; transparency of food data/contract selection independent; bidding processes
10.3389/fbloc.2021.613346	O1-O3	Content control/slow adoption/necessity for regulation and policy updates
10.3390/s20102990	P1-P6	Deep learning/notification functions/smart transportation/security endpoints/automation/revolutionary innovation
10.1002/ett.4059	Q1-Q4	Precision irrigation; accurate assessment on requirements/open communication/spoofing, sensor, critical attacks/optimal resource usage
10.1080/09064710.2020.1840618	R1-R2	Millions of transactions per day/trusted negotiation
10.1007/s10586-020-03092-4	S1-S2	Repelling system; motion sensors; ultrasonic sound device generator/reliable data transmission; low-cost features
10.1108/jstpm-03-2020-0065	T1-T4	Integrity verification/efficiency and visibility/business disruption/platform mobile app for financial aid

Source: Authors own synthesis.

The last step in the content analysis (Table 2) is the frequency analysis. The research proposed two main category groups which underline either the advantages and opportunities blockchain technologies can determine in agriculture, or the threats, limitations or weak points that blockchain technologies might impose on the agriculture sector and all its connected dimensions.

Table no. 2. Frequency Analysis

Category	Recording units	Frequency	T.
Transparency	A1,A5,A7,B4,C1,C2,D2,F1,G3,H1,H3,H4,I2,J2,J3,L2,N1,O1,Q2,R1,T2	21	111
Traceability	A1,A2,A3,A4,A7,A12,C1,C5,D2,F1,G1,H2,H4,I1,I2,J1,J2,J3,L1,N2,P2,P3,R1	23	
Security	A1,A2,A5,A6,A11,A12,F1,G2,G7,H2,H4,I2,J2,L1,L3,N2,O1,P2,P4,R1,R2,S1,T1	23	
Efficiency	A2,A3,A8,A9,A12,C1,C3,D2,D3,E1,E2,E3,F1,G1,G3,H1,H3,I3,J2,J3,J4,J5,K1,L4,L5,P2,P5,P6,Q1,Q4,S2,T4	32	
Confidentiality	A6,A11,A12,D3,G2,H3,I3,N2,R2	9	
Immortality	A3,D3,J3	3	
Transparency	B2,C4,C6,F2,G4,M1,M3,O3,T3	9	52
Traceability	B1,C4,M1,M3,T3	5	
Security	B1,B2,D1,D4,D5,G4,G5,G6,H5,M1,M3,O3,Q3,T3	14	
Efficiency	A10,B1,B2,B3,B4,C7,C8,D4,G8,H5,I4,M2,O2,P1	14	
Confidentiality	B1,B2,D5,F2,G4,G6,M1,M3,O3,T3	10	
Immortality	-	0	

Source: Author's own synthesis.

Each category group was further divided into the six characteristics of blockchain technologies – transparency, traceability, security, efficiency, confidentiality, and immortality of data. The results of the content analysis showcased that the majority of the research was focused on the advantages and opportunities of the blockchain technology and applications for the agriculture sector of the economy. The other category group has amounted 52 mentions. From this initial observation, it can be underlined that the focus of the majority of scientific articles on the topic of implementation and usability of blockchain technologies in agriculture is directed towards the positive aspects of such a shift in strategic direction. This is indeed valuable for the entire scientific world, although it is of paramount importance to be able to assess the possible and probable threats of a potential shift towards e-agriculture with the help of blockchain technologies.

Among the most accountable characteristics of the blockchain technology are the transparency and traceability of all transactions, also known as the major elements visible on the cryptocurrency market (44 mentions of the two characteristics). The main characteristic approached from the perspective of blockchain technologies implementation in agriculture has been the efficiency that blockchain would determine in this sector. Moreover, the limitations or threats of an adoption of blockchain technologies in agriculture are constructed around the security and efficiency of the model. Apparently, just like any other ICT and IoT system, the blockchain technology might be liable to cyber-attacks, compromising the whole mechanism especially around the information nodes. The content analysis has successfully identified the topics that could be further developed, as well as those that might pose difficulties to a smooth implementation of blockchain technologies in agriculture and to the transitioning towards e-agriculture.

Discussion: New potential business model as resulted from the content analysis

The implementation of the blockchain technologies into the agribusiness is, at this moment, not a straightforward option, as such an outburst of technology, IoT, skilled human capital, machine learning, AI applications, etc., does not seem easy to grasp, and to financially cover, especially in the agriculture sector, where the medium global margin does not top 7%. Nevertheless, the risks normally imposed by undergoing traditional agriculture activities at large scale can be very easily diminished with the usage of blockchain technologies. As expected, the research cast a light on the prospects of going towards the future and adopting blockchain technologies in e-agriculture, as well as on the downfalls of a timely implementation without first forecasting the possible and probable outcomes.

The results of the study showed that, between 2020 and early 2021, scholars have proposed and developed different scientific articles related to the topic of blockchain technologies in agriculture, and to the extent a particular application of blockchain technologies could enforce on the development of agribusiness across the world. The articles have focused on countries that are known for their mainly

agricultural economy, such as India, as it is clear that agriculture in itself is intensively clustered in emergent economies, particularly performed under the roof of SMEs. The latter are economic agents heavily reliant on their volumes of production and their revenues, as their profit margin and reinvestment strategies are insignificant or nonexistent. A blockchain application development is priced between USD 5000 and USD 200000, depending on its complexity and project requirements. Therefore, it is wise to first look into how this price range can actually impact the agribusiness, and if the market potentially is ready for such a leap of faith.

Consequently, the disparity in this case is the fact that research is focused on positive aspects of blockchain technology application in agriculture, while the limitations of the model seem to be two times less discussed. It is important to look further for options of socioeconomic growth and development. Nevertheless, the means must be strategical. On cryptocurrency markets, where the trade is focused on intangible assets, blockchain technologies are the best solution. A market trading tangible goods changes the premises. Agricultural goods are prone to a wide range of risks. The main threats in the global arena are imposed by climate change, disequilibrium of natural habitats, and growth of world's population, deforestation, intensive fishery activity, and social disruptions. The inequalities across the globe are far more overwhelming as they might appear, and choosing the right solution seems a bit far stretched in any perspective.

From an opportunistic perspective, the research returned on the information that blockchain technologies in agriculture would determine a sharp increase in the efficiency of the whole system. At the border of 18th century traditional agriculture stands tall a new business model that might as well have been alien. Imagine a plateau of greenhouses harboring data sensors for precision irrigation, temperature control, light control, with machine learning and AI applications continuously monitoring the accelerated growth and development of the plants, and next to it a building of servers and computer powered units to store, track and forward all that information, in order to instantly obtain digital certificates for the quality standards of food, to link the farm to the food supply chain through trust certificates, to monitor and save all the transactions, to bid and negotiate smart contracts, and to develop and maintain communication and global trade relationships in a controlled, traceable, transparent, efficient and secure platform, all that topped by the best possible crop yield. The scale of such an operation can be, of course, downgraded to suffice the necessities of different sized farms and e-agribusinesses. Nevertheless, it is still something that might take a while until is no longer part of the niched knowledge economy, and becomes a standard business model across the globe.

The next characteristics that make blockchain technologies attractive for the agribusiness are transparency and traceability, and refer to the fact that on the blockchain platform any business is identifiable through a user profile, a history of all interactions and transactions, and several performance indicators of each user available. This ensures the drop of fraud and of inequalities during bidding between small and medium sized farms and large farms. Moreover, it represents a mean that allows for easy access to all sorts of data on each particular user, including financial aspects such as index insurance, timely payments, etc. At the same time, the blockchain technologies offer the possibility to unlock global trade to all the users regardless of their geographical position.

From the perspective of limitations to the blockchain technology application, security is one of the most discussed topics in the analyzed scientific articles. Although this technology brings cryptographic keys for authentication and digital signatures, privacy control, a decentralized, secure, shared database, IDS to identify security incidents, etc., there are still concerns regarding blockchain fork issues, impersonation attacks, password breaches, compromised session keys, and many others, in particular due to the lack of regulation, trust among stakeholders and uncertainty with regard to blockchain technologies.

Conclusions

Blockchain technology is the system behind cryptocurrencies, and mostly comprises of elements and processes that are realized and represented by advanced software, high-tech hardware, and the IoT. In its majority, the blockchain application revolves around knowledge, and expertise in the sector of ICT. This dimension, obviously, is not the go to framework for strategies in agriculture. Moreover, we stumble upon the question of whether from a knowledge perspective the e-agriculture is a plausible

business model at global level. The blockchain technology is something extremely new, not entirely known and understood. Agriculture, since its early forms, relied heavily on the input and labour of human capital, and the general usage of blockchain technologies in agriculture relies on training the human capital. There are numerous platforms applying the technologies of blockchain infrastructure to the agricultural sector. Nevertheless, the simple existence of those platforms does not imply the transitioning towards e-agriculture. Although the costs of entering the market are zero, the knowledge on the new business model is paramount, and the financial capability to invest is necessary to become competitive. In the end, it is only a matter of time until this will represent the norm, although we cannot consider that this new business model will be globally adopted in the near future.

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