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Study:

Application of blockchain in agriculture and food supply chains in China

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Preface

This study was carried out by the Sino-German Agricultural Centre (DCZ), a platform jointly financed by the German Federal Ministry of Food and Agriculture (BMEL) and the Chinese Ministry for Agriculture and Rural Affairs (MARA).

The purposes of the study are as follows: to review the application of blockchain technology in the agriculture sector in China, to analyze recent developments and various applications in the sub-sectors of agriculture and food, to investigate major policy support from the Chinese government in the promotion of blockchain in agriculture, and to identify key challenges for the further development of blockchain in the agriculture sector in China.

This is study has been carried out by reviewing relevant academic papers, news reports and policy documents and initiatives in English and Chinese.

Key findings from this study

- Blockchain technology has been transforming various sectors, including agriculture.
- Food traceability and transparency, agricultural insurance and financing, smart farm data management, and e-commerce and online marketing are promising sub-sectors for the application of blockchain in agriculture.
- The Chinese government has laid out a number of policies directly and indirectly supporting this sector, such as upgrading digital infrastructure, proposing rural revitalization initiatives and introducing the digital yuan to compete against cryptocurrencies.
- GoGoChicken, a Huawei smart farm cloud platform, and others are among the more than 500 blockchain initiatives underway in China.
- Scaling, lack of digital competence, infrastructure gaps, increased oversight of big tech and the US–China tech war are major challenges in the application of blockchain in the Chinese agriculture sector.

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1. General introduction to blockchain

The development and use of Bitcoin and other cryptocurrencies since 2008 has ushered in a new era in which financial transactions may not require trusted financial institutions such as banks but instead can be carried out digitally (Nakamoto, 2009). 'A blockchain is a digital transaction ledger, maintained by a network of multiple computing machines that are not relying on a trusted third party' (Kamilaris et al., 2019, p. 640). A blockchain is an open and secure method of storing and distributing information that operates without a central server. A blockchain is a database containing a record of every transaction between users from its creation onward. It is a secure, distributed database that is shared by the different parties without an intermediary, allowing each user to verify the validity of the chain. Therefore, blockchain technology allows peer-to-peer transactions to take place transparently without a bank or middleman in the agriculture sector (Xiong et al., 2020). A blockchain is a distributed database of records in the form of encrypted 'blocks' (smaller datasets), or a public ledger of all transactions or digital events that have been executed and shared among participating parties and can be verified at any time in the future. Each transaction in the public ledger is verified by the consensus of most participants in the system, and information, once inserted, can be removed (Nakamoto, 2009).

'Key feature of a blockchain is its ability to keep a consistent view and agreement among its participants (i.e., consensus), (Bano, 2017), even if some of them might not honest' (Kamilaris et al., 2019, p. 641). The most commonly used consensus in Bitcoin is called 'Proof of Work' (PoW), which uses computer nodes (sometimes called 'miners') to solve difficult computational tasks before performing and validating transactions (Bentov, Gabizon and Mizrahi, 2016). Because PoW requires miners to use computer power constantly, it results in increased demand for hardware and energy. To lessen the negative impacts of PoW, another consensus approach called 'Proof of Stake' (PoS) is gaining more attention. PoS involves 'giving each decision-making power to entities who possess coin within the system, putting them "on stake" during the approval of transaction' (Bentov, Gabizon and Mizrahi, 2016). In this system, computer nodes known as 'validators', rather mining (computing) the blockchain, validate the transaction to earn a fee (Kamilaris et al., 2019). This saves computing power and energy.

Currently, blockchain is considered and used by conventional financial institutions around the world, and up to 15% of financial institutions use blockchain for their transactions (IBM, 2017). Furthermore, blockchain application has been widened to handle administrative records, digital authentication, and verifying and tracking intellectual property, smart contracts and health records, as well as tracking products through supply chains from manufacturer to distributor to supplier. The agri-food sector is the latest and the most prominent sector to embrace this technology.

2. Blockchain application in the agriculture and food supply chain

The agri-food supply chain involves numerous actors, such as farmers, shipping companies, wholesalers and retailers, distributors and groceries (Kamilaris et al., 2019). The agri-food supply chain includes production, processing, distribution, retailing and consumption (Figure 1) of food. Blockchain could assign digital identifiers to agri-food products through the whole supply chain, which would make these products traceable and also provide information about their growth conditions, quality and expiry dates. In addition, exchanges of agri-food products based on complex and paper-based transactions may not be transparent, may pose certain risks, such as fraud and the involvement of middlemen, and may also increase the costs of transactions. The use of blockchain could eliminate or at least reduce the aforementioned problems, thereby increasing the integrity, transparency and traceability of the whole system. Major applications of blockchain in the agriculture sector are as follows (Kamilaris et al., 2019):

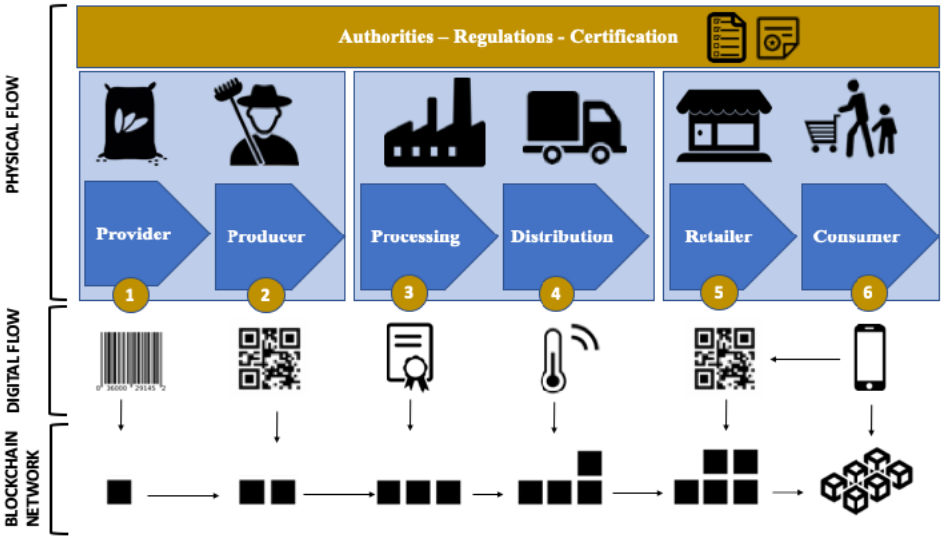

Figure 1. Simplified food supply chain (Kamilaris et al., 2019)

A) Food supply traceability and transparency

One of the most of widely used applications of blockchain technology in the agriculture sector is food tracing, which provides improved food safety and transparency. Walmart and Kroger (US supermarket chain stores) were among the first companies to include blockchain in their supply chains. An initial case study on packages of mangoes showed that it took 6.5 days to identify the origin of the fruit and the path it followed with traditional methods, whereas with blockchain this information was available in a few seconds (Wass, 2017). The French supermarket chain Carrefour has also implemented blockchain tracing of their animal products. Radio-frequency identification (RFID) technology is widely used in food tracing and allows the tracing of goods through all the steps of a production chain by using a simple tag or QR code (Antonucci et al., 2019). Tian stated that the use of RFID and blockchain technology in the agri-food supply chain improves food safety and quality and decreases losses during the logistics process. For example, the agricultural conglomerate Cargill Inc. use blockchain to let customers trace their turkeys from the store to the farm that raised them (Bunge, 2017). In short, blockchain bolsters food security, food safety and food integrity.

B) Agricultural insurance and financing

Agricultural production is very vulnerable to natural and man-made hazards and risks, such as drought, flood and pest or disease outbreaks. Although many governments compensate farmers for some of their lost harvest in the event of a disaster, building a more reliable and accurate insurance system would decrease unwanted liability and more fairly distribute the risks. In a Hackathon example developed in Kenya, farmers provide specific parameters of their crop and farm, such as information on crop health and soil and land management, to access credit and insure their farm (Hackathon, 2017). In China, online payment services such as Ant Financial and WeChat Pay enable farmers to make cashless transactions and access various online credit and insurance services through their mobile apps.

C) Smart farm data management

Smart agriculture uses digital technology and the internet of things (IoT) with various modern data collection and analysis technologies, such as unmanned aerial vehicles (UAV), sensors, and machine

learning (Xiong, 2020). According to Xiong, 'The blockchain technology serves to store data and information that various actors and stakeholders generate throughout the entire value-added process, from seed to sale, of producing an agricultural product' (Xiong, 2020, p. 3). Storing and managing agricultural data through centralized servers would be risky, so distributing these data to various computers and servers through blockchain not only improves security but also optimizes its performance. In an ideal blockchain-based smart farm system, farmers and other relevant actors would be able to obtain real-time data on conditions of their farm, crop, soil and water situation and make timely management decisions. This would optimize the farm's production through efficient resource allocation and increased trust and transparency. However, it would not lower the bar for farmers to operate these systems; digital skills would be crucial to achieve its intended goals.

D) E-commerce of agri-food products

E-commerce and trade of agricultural products require transactional, logistical and marketing coordination among various actors in the supply chain to reduce excessive operational costs. Blockchain technology may provide solutions to these e-commerce problems in information security, supply chain management, payment methods and consumer confidence and reduce costs for farmers. In recent years, Chinese small farmers have been using various retail, social media and video platforms to market and livestream their products directly to consumers through blockchain's facilitation of logistical and payment issues.

3. Policy support from the Chinese government

A) Chinese president Xi Jinping's endorsement

In 2015, blockchain technology was mentioned in China's 13th Five Year IT Plan (2016–2020) as a vital tool to accomplish the country's modernization. In October 2019, Chinese president Xi Jinping gave a speech in which he called on China to 'seize opportunities' presented by blockchain. This was an extremely important development for the blockchain industry. Prior to this announcement, more than 500 blockchain projects had already been registered in China by tech heavyweights such as Huawei, Alibaba, Baidu and Tencent. Soon after, a blockchain test zone in Hainan Province was set up to experiment with the cryptocurrency Huobi, which is sponsored by Baidu (Kharpal, 2020).

B) Digital yuan

From its inception, blockchain technology has heavily relied on cryptocurrencies such as Bitcoin to carry out online transactions. The potential exploitation of cryptocurrencies for criminal activity and money laundering, along with the prevalence of online payments and cashless transactions, has accelerated demand for regulated and authorized digital currency. In 2018, Facebook floated a pilot digital currency initiative called Libra in partnership with more than 20 financial and private sector institutions around the world. Theoretically, Libra could replace the US dollar and other major currencies for any financial transaction, if it were universally accepted and used. However, the US Federal Reserve and other central banks resisted such a drastic change on grounds of fiscal sovereignty, among other concerns, and the project had to be discarded.

Although China is home to the world's most widespread cashless online services, including Alipay and WeChat Pay, the need for government-issued and regulated digital currency is strong. In October 2020, the government of Shenzhen municipality issued 10 million Yuan (1.5 million USD) worth of digital currency by lottery as a pilot project in which people can win and claim the currency by downloading the Renminbi app on their mobile devices. They can then spend the money at 3,000 authorized

merchants in the city (Kharpal, 2020). Unlike cryptocurrencies like Bitcoin, the digital yuan is directly issued and controlled by the Chinese central bank. It has been a major step in the digitalization of Chinese currency, which is an essential element of blockchain technology (Rabinovitch, 2020).

C) China's rural agriculture digitalization development plan for 2019–2025

The Ministry of Agriculture and Rural Affairs and the Central Cybersecurity and Information Committee of China jointly published the **'Rural and Agriculture Digitalization Development Plan for 2019–2025'** on December 25, 2019. The plan provides a blueprint for the digitalization of agriculture and rural areas. It outlines five important goals (MARA, 2020).

- **First**, it calls for establishing a basic data source system with a main focus on natural agricultural resources, agricultural cropping, rural collective capital, rural housing and new rural marketing integration as the five main data points that will be the basis of rural development.
- **Second**, the plan calls for improving the digitalization of production and sales; accelerating the digitalization of cropping, animal husbandry, and fisheries; diversifying new industries, covering the full process of quality control; and improving digital agriculture productivity.
- **Third**, the plan calls for promoting the digital transformation of management and services; establishing and improving rural management decision-making support systems and early-warning systems for the entire industrial chain of important agricultural products; and building a digital agricultural rural service system, an intelligent monitoring system for rural human settlements, and a digital rural governance system.
- **Fourth**, the plan calls for strengthening key technology and innovating equipment; strengthening key common technology research; strengthening strategic advanced technology and technology integration, applications and demonstrations; accelerating the development of agricultural artificial intelligence research; and improving the leading role of the digital development.
- **Fifth**, the plan calls for strengthening the construction of major engineering facilities and implementing major national agricultural and rural big data centers, as well as agricultural and rural aerial–ground integrated observation systems, national digital agriculture and rural innovation, and other major engineering projects to enhance the support capacity of digital agriculture and rural development.

This plan laid out the framework and digital infrastructure development required for the application of blockchain in the agriculture sector in China.

4. Blockchain cases in various agriculture and food sub-sectors in China

A) GogoChicken (步步鸡)

The GogoChicken program is a Jiangsu-based poultry blockchain project which was jointly established by Zhong'an Technology and the Jingjiang Huayuan poultry cooperative in Jiangsu Province. Its goal goal is, among others, to alleviate poverty. They use ankle bracelets to monitor each chicken's movement and behaviour through GPS tracking, and this information is then available through the web. The company aims to build trust among consumers by documenting the origins of their food. Based on the features of blockchain technology, it ensures that all data generated from each chicken from chick to adult and from the farm to the table is recorded and tamper-proof traceability is

achieved.
As of 2019, 100,000 birds had been tagged with GPS bracelets, and the company plans to tag 23 million birds in the next three years. Their effort has been documented in a book entitled *Blockchain Chicken Farm* by Xiaowei Wang, which was also profiled in the *New York Times*.

Figure 2. Tagged Gogochickens
(https://www.shangyexinzhi.com/article/298494.html)

B) Walmart–IBM–Tsinghua

The supermarket chain store Walmart, in collaboration with IBM and Tsinghua University, initiated an experimental blockchain project in China in 2018. Through blockchain technology, Walmart and consumers will be able to trace agri-food products in Walmart stores. Each item will have a tag and QR code that will enable a consumer to know not only where it was produced, but also how it was produced, delivered etc. According to Xin Ba, 'The project is predicted to eventually cover the entire global agri-food supply chain and could save as much as a trillion US dollars in coming decades' (Xin Ba, 2019).

C) Blockchain Big Farm

Blockchain Big Farm is a project initiated by the Jiangsu Central South Construction Group Ltd. (Huanan Jianshe) and Heilongjiang Beidahuang Agriculture Ltd. This is an integrated blockchain project that uses a 'Platform + base + farmer' mode of production, in which food can be traced from its origin to the table to ensure the safety and quality of agricultural products sold. This blockchain farm is designed to produce Wuchang rice and other grain products.

D) JD.com and beef from Mongolia

China's second largest ecommerce giant, JD.com, is working with Kerchin, a Mongolian beef producer, to track the production and delivery of frozen beef.

E) Ant Financial and Bayer

In August 2018, the Wuchang municipal government of Heilongjiang Province and Alibaba jointly announced that Tmall (the e-commerce arm of Alibaba) and Ant Financial would collaborate on the production and distribution of the famous Wuchang rice. Starting September 30th of 2018, each bag of Wuchang rice sold on Tmall would have an 'ID card'. Consumers using Zhifubao (Alipay) scan would get detailed information about the rice, such as where and how it was produced, what kinds of seeds

and fertilizers were used and its full logistical and delivery history. This kind of ID requires that all stakeholders be transparent and trustworthy throughout the entire agri-food supply chain.

In October 2019, Ant Financial and the crop science division of Bayer announced their cooperation on blockchain agriculture in China. This joint effort intends to combine Bayer's advanced crop and farming technology with Ant Financials' advanced payment, marketing and other financial services to build a holistic and digital agri-food supply chain. The Dangshan pear plot in Anhui Province is an example of their collaboration (Pollock, 2019).

F) Huawei smart farm cloud platform

Yuan Longping (a famous Chinese scientist who genetically modified rice seeds) and his research group have successfully experimented with salt-resistant rice ('seawater rice') in the Chengyang district of Qingdao with help of Huawei Cloud. Huawei has also rolled out the Agriculture Wotu Cloud Platform, which integrates seed, soil, planting, growth, processing, warehousing, logistics and sales data so that consumers and other stakeholders can trace and share information regarding specific agricultural products. Although this platform has been successfully used in rice production in Shangdong Province, wider application of the platform has yet to materialize.

G) Wine Chain

Wine Chain is a blockchain platform for Ningxia-based wine production that aims to address trust, quality and counterfeiting issues and to build credibility and brand recognition for Ningxia-produced wine by allowing customers to authenticate and trace the wine they purchase and consume.

H) Joyvio and HC International Inc.

Joyvio, the largest globalized fruit company in China and HC International Inc. established a joint blockchain project with an initial fund of one billion yuan to provide a trustworthy, traceable and sustainable digital platform to grow and trade fruit and other agricultural products (Sina, 2020).

5. Challenges and outlook

A) Scaling and coordination

Chinese agriculture is made up of small individual farms, collective farms and large state and private farms. Implementing blockchain technology throughout the agri-food supply chain would face some challenges, especially for China's smallholder farms – the most common type of farm – where full mechanization and digitalization would come with huge costs and investments. These additional costs would significantly impact farmers' willingness to use blockchain technology. Scaling up agricultural blockchain to a provincial or national scale requires investment, coordination and support from both the public and private sectors.

B) Competence and digital skills

The rural population in China, as in other countries, has lower levels of education and digital skills and tends to be much older and more prone to digital illiteracy than the urban population. In addition, rural brain drains in which young and educated people leave rural areas for cities in search of better opportunities and living standards make the digital skill discrepancy an enormous obstacle to realizing the full potential of agriculture blockchain technology in China. However, the Chinese government has

proposed a new rural revitalization plan to address such problems and keep and attract talent in the rural areas. More training and technical assistance along with user friendly modifications and improvements in relevant hardware and software involved could also alleviate these problems.

C) Digital infrastructure

Although the Chinese government has invested a great deal of money in digital technologies such as 5G and fibre-based internet infrastructure, a huge regional disparity persists between China's coastal metropolitan areas and more rural and interior regions. For instance, most of the 5G installations in 2020 occurred in developed coastal regions of China. Because vast swaths of agricultural areas are concentrated in less developed interior and western regions, building a solid digital infrastructure is of paramount importance for transforming these regions into blockchain-oriented agriculture.

D) Increased oversight and regulation on big tech

The *Wall Street Journal* reported that, in December 2020, the Chinese State Administration for Market Regulation opened an antitrust investigation into Ant Financial, a financial subsidiary of the e-commerce giant Alibaba, over anti-monopoly and financial regulation issues (Lin et al. 2021). The Chinese government's increased oversight and regulation of big tech companies, such as Alibaba, Ant Financial, Tencent and JD.com, on the issues of monopoly, fair market competition, data privacy and sovereignty will have major and lasting impacts on the future of Chinese tech, and hence of blockchain application in the agriculture sector. On January 11, 2021, China released a draft rule for regulating big technology firms with regard to anti-trust and data privacy that is similar to the EU's already enacted *Digital Market Act and Digital Services Act of 2018* (Kharpal, 2021).

E) Ongoing US–China tech war

In 2019, the US Department of Commerce added a number of Chinese tech companies to its 'Entity List' on the grounds of alleged national security and human rights violations. This listing and other executive actions have banned US tech companies from selling hardware and providing software services to the companies on the list. This has severely restricted some Chinese companies' access to US-made chips, software and other technologies. For instance, Intel and Qualcomm are banned from supplying chips to Huawei, and Google has terminated services to its Android system on Huawei devices after the enactment of the ban. Going forward, how the US–China tech war will play out could create enormous challenges but also opportunities for Chinese home-grown technology to catch up and self-innovate, which would be an essential component of future blockchain development in the agriculture sector in China.

6. Conclusion

Food security and rural revitalization are the key challenges for the Chinese agricultural sector. In addition, smaller size of per capita farmlands and lower agricultural production efficiency have accelerated the need for digitalization in order to fulfill China's self-sufficiency in food and also to insure stable income for farmers. Furthermore, increased digital sophistication of consumers and a rising demand for safety and high quality of foods have created a niche for blockchain application in agriculture. The Chinese government's determination to consolidate the achievement of extreme poverty eradication and rural revitalization in the 14th in five-year plan also serves as a catalyst for this transformation. The application of blockchain in agriculture could lead China into a new phase of economic and rural development.

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