Congressional Research Service
Informing the legislative debate since 1914

IN FOCUS

May 12, 2021

Blockchain Technology and Agriculture

Some stakeholders in the technology, agriculture, and food sector have advocated for the use of blockchain technology to trace agricultural products as they move through the supply chain and to verify their authenticity. Many expect use of blockchain technology to increase in this sector. Congress may consider federal investments in blockchain technology research, technical assistance, and infrastructure to support emerging applications of this technology. Congress also may face questions regarding the regulation of particular uses of blockchain technology.

What Is Blockchain Technology?

Blockchain is a distributed ledger technology for securely recording and authenticating information about sequential events or transactions. It is commonly associated with the financial services sector due to its use in cryptocurrencies, but it also has potential applications in agriculture.

Unlike traditional data systems, blockchain technology does not rely on a central authority to maintain records or verify transactions on behalf of users. Instead, members of a blockchain platform each have access to automatically updated copies of all transactions. Every transaction is recorded in a new *block* in the chain. Each block has several pieces of information: the data itself; a *hash* value, or alphanumeric string, cryptographically determined by the data; and the hash of the previous block in the chain.

Selected Blockchain Qualities

Tamper-Evident. The data in each block in a blockchain has a cryptographically determined *hash* (an alphanumeric string). Each block contains the hash for the current and prior transactions. Altering data inherently alters its hash. Thus, data tampering is evident when a block's hash and the next block's record of the prior block's hash do not match.

Tamper-Resistant. Blockchain community members each have access to automatically updated copies of the blockchain. If the data in one copy is tampered with, it would not match the other copies, and the community would not accept that chain as the consensus chain of events.

Transparent. Although each member of a blockchain community may not have permission to read the data in each block, each member has access to a current copy of the ledger and can view changes and additions to the chain.

Decentralized. Blockchain does not rely on a central authority to maintain data. Consensus among the community serves this role.

Designers of a blockchain can customize its rules depending on the level of trust among community members and other variables. For example, the blockchain community can be public or private, with varying levels of trust granted and information accessible to different members.

Potential Applications in Agriculture

Recent outbreaks of foodborne illness and investigations of fraud in the organic food sector have illuminated weaknesses in information about agricultural supply chains. Proponents view blockchain technology as a potential solution to certain existing concerns, such as the following:

- reducing the time it takes to identify the source of foodborne illness;
- targeting food for removal as opposed to the loss of entire stocks; and
- ensuring claims made about food (e.g., authenticity of being organic).

Potential Challenges for Agriculture

While blockchain technology is a potential solution to some issues in agriculture and food supply chains, certain general and sector-specific challenges may impede its utility and adoption. Another consideration is that in many instances, solutions that are simpler and less resource-intensive than blockchain technology may adequately address specific needs. Prospective users may consider whether the potential benefits of blockchain technology outweigh any limitations or costs particular to their situations.

Infrastructure: Internet Access

Blockchain requires an internet connection to upload new data to the blockchain and to maintain updated copies of the ledger held by community members. Lack of internet access, or inconsistent access, in locations where agricultural products originate and are processed and packaged may impede successful use of this technology.

Standards and Interoperability

As with many new and emerging technology applications, there are not yet consistent standards and digital platforms to facilitate the shared use of blockchain technology by multiple users across the agriculture and food sector. All members of a single supply chain must adopt the same standards and platform to participate in a shared blockchain. Lack of adoption, or adoption of different standards and platforms, could exclude some suppliers or providers of other services (e.g., packaging, transportation) from certain supply chains. Sunk costs of initial technology investments could tie participants to a particular supply chain and impede their flexibility to work with other elements of the food system.

Technology: Bridging the Digital-Physical Divide

In the example case of cryptocurrency, there is a direct relationship between the digital data on the blockchain (i.e., the currency transactions) and the product (i.e., the currency's value). In agricultural applications, digital data in a blockchain represents events associated with a physical product. These events must be recorded, by manually recording data or through manual or automated scanning of digital markers on the product or its packaging (e.g., RFID tags, QR codes). Internet of things (IoT) devices—which wirelessly connect to the internet and can transmit data from sensors and other technologies—may be used to automatically upload relevant data to the blockchain. Designers of blockchain systems for agricultural products may consider these and other options. Manual data entry could introduce errors that would be immutably recorded in the blockchain, and protocols to address such errors may be required. Various types of digital markers may require different physical infrastructure or handling methods.

Example Use Cases

Participants in agricultural supply chains have predicted, piloted, or adopted the use of blockchain technology to achieve goals, which include improving food safety, authenticating high-value products, and verifying compliance with the terms of certification programs. Selected examples are discussed below.

Food Safety: Walmart Leafy Greens

Walmart is the leading grocery retailer (by grocery sales) and the largest purchaser of locally sourced produce in the United States. In 2016, Walmart piloted the use of blockchain to trace fresh mango and pork through its supply chain. The mango pilot project demonstrated that, with blockchain, Walmart could trace the source of mangos in a store in 2.2 seconds, versus seven days with traditional methods. In 2018, Walmart launched the *Walmart Food Traceability Initiative*, which requires its suppliers of leafy greens to participate in a blockchain network. The initiative aims to enable tracing the source of contaminated products within seconds and to increase the efficiency and precision of food recalls. For example, the blockchain could assist in rapidly identifying the source of lettuce contaminated with the bacteria *Escherichia coli*. Since September 2019, all suppliers of leafy greens to Walmart have participated in its blockchain network.

Premium Sourcing: Beefchain

Consumers often pay a premium for beef from free-range and grass-fed cattle, compared with beef from cattle raised conventionally. Ranchers who employ these premium practices may not recoup the full price premium without trusted recordkeeping. Beefchain is a private company that has partnered with Wyoming ranchers to enhance the traceability of their management practices throughout the supply chain, using a combination of blockchain technology and monitoring with IoT devices. Beefchain aims to allow ranchers to benefit from premium pricing and assure consumers of the authenticity of the beef they purchase. Beefchain is the first blockchain solution approved by the U.S. Department of Agriculture (USDA) under its Process Verified Program (PVP).

Certification: USDA National Organic Program

Misrepresented sourcing of agricultural products is a concern for suppliers, retailers, and consumers of organic agricultural products. Organic fraud occurs when a product is presented as being certified but was produced with prohibited practices. USDA's Agricultural Marketing Service (AMS) administers the National Organic Program (NOP) and has implemented policies in recent years to better investigate and enforce against fraud. Some have proposed using blockchain technology to verify adherence to NOP standards throughout organic supply chains. In a 2020 proposed rule on *Strengthening Organic Enforcement*, AMS anticipated that blockchain technology, referred to as "digital ledger technology," will play a role in supply chain traceability and encouraged the development and use of this and other electronic tracking systems for certified organic products.

> "AMS expects electronic tracking systems, including digital ledger technology (DLT), will play an essential role in supply chain traceability" related to USDA's enforcement of its certified organic standards. (85 *Federal Register* 47536)

Congressional Interest

Congress has expressed interest in diverse applications of blockchain technology, including agricultural applications. In 2018, two subcommittees of the House Committee on Science, Space, and Technology held the hearing *Beyond Bitcoin: Emerging Applications for Blockchain Technology* (H.Hrg. 115-47). This hearing included testimony from Walmart's vice president for food safety, among other witnesses. Various public and private interests may call on Congress to consider regulating the use of blockchain technology in the agriculture and food sector. The Congressional Blockchain Caucus, launched during the 114th Congress, seeks to study and understand the implications of blockchain technology and advocates for a limited regulatory approach.

Congress also may consider whether to appropriate funds to further develop this technology for use in agriculture and food supply chains. Areas of opportunity may include investments in rural broadband; research and development of technologies and infrastructure to record and share blockchain data (e.g., IoT devices, digital markers, software, blockchain design); economic and social science research on potential blockchain applications; and federal agency staffing and coordination, if federal programs come to require new and specialized knowledge. The House reports accompanying appropriations bills for FY2020 (H.Rept. 116-107) and FY2021 (H.Rept. 116-446) encourage USDA's National Institute of Food and Agriculture to "coordinate research to reduce the risk of foodborne illness through the use of blockchain technology."

For more information on blockchain technology, see CRS Report R45116, *Blockchain: Background and Policy Issues*, by Chris Jaikaran.

Genevieve K. Croft, Analyst in Agricultural Policy

IF11829

Disclaimer