

Enhancing Food Supply Chain Governance with Blockchain

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Food systems in Asia are in critical need of reform. Accurate information on food sources and quality is crucial in developing Asia, where robust food systems are essential for public health and the long-term development trajectories of economies (Sheth 2020). Farmers in the region also face persistent exploitation by intermediaries and corporations (Sivaramakrishna and Jyotishi 2008). Blockchain can be a valuable tool for addressing these food supply chain challenges by opening avenues for enhancing redistribution and accountability for both food producers and consumers.

How does blockchain work?

Blockchain is a system that securely validates and stores digital information on a computer network through a *consensus-based* mechanism. It differs from central validation, which is used in banking, such as when a customer withdraws from their bank account. The bank, which solely holds the ledger of all customers' transactions, centrally validates the request. The new transaction is then added to the ledger, and the withdrawal proceeds if validated.

With blockchain, however, *all* members participate in a decentralized network and hold a full copy of the ledger. When a new transaction is initiated, the request is packaged into a “block” that multiple other members must validate. If the network reaches a *consensus* that the request is legitimate, the newly validated block gets added to the “chain” of previously accepted blocks. Thus, it is easy to add data but challenging to remove them from the blockchain ledger (Nofer et al. 2017).

Preventing food adulteration and wastage

Between 2012 and 2019, Indian authorities found that the percentage of adulterated food samples—the quality of which had been intentionally debased and failed to meet legal government standards—nearly doubled from 15% to 28% (Sheth 2020). Blockchain can help resolve this issue by tracing food products' exact path from farm to consumer (dos Santos et al. 2021). Every unit of produce a farmer sells can be recorded as a non-fungible token (NFT)—a uniquely identifiable digital asset that is validated and stored on a blockchain (FAO 2022). As primary products traverse the supply chain, any processing they undergo is recorded as subsequent blocks on the ledger. Since each block is validated across multiple nodes in the network, no actor in the supply chain can unilaterally modify the data to introduce falsehoods, which enhances the legitimacy of the information without relying on a centralized server (which could be more easily compromised). Startups like CattleProof have used blockchain to verify the production data of beef products (Jemima 2022).

However, this technology can be even more powerful when used by governments. Government-issued NFTs could be the next digital incarnation of food standards labels. As a label would have to be verified across the network, errant producers could not procure false certifications. Authorities could also exercise finer control, certifying producers on a per-transaction level. The blockchain could issue NFTs only when producers adhere to mandatory preceding steps tracked on the ledger. A cultural dietary certification or environmental standards credential might require proof of traveling through

designated checkpoints in the supply chain, failing which, the label would not be generated. Regulators could even fragment the NFTs into fractional NFTs (F-NFTs), issuing the certification one component at a time as the producer fulfills the requirements.

EnergyTag, a private energy standards initiative, issues NFTs hourly, allowing consumers to track the source of their electricity and its carbon emission levels and alter their consumption decisions accordingly (EnergyTag 2023). Similarly, governments could co-opt market forces to encourage compliance among producers. If the ledger is made public, consumers would be empowered to withdraw support for producers who fail to uphold expected standards, allowing real-time market signaling to producers.

Governments could also reduce food wastage using blockchain. By tracking the last available record of a particular NFT's interaction with the blockchain, authorities could identify the supply chain stages at which food fails to reach consumers. This could then inform the redesign of food systems to mitigate losses.

While such a full-fledged agrifood blockchain solution has not yet been built, the Canadian government has piloted an NFT credential that chronologically logs civil servants' qualifications (Leal 2019). A similar design could track food products' movements through the supply chain, ensuring that consumers' consumption can be verified as unadulterated.

Protecting farmers from exploitation

Another challenge on the producer side is the exploitation of contract farmers due to corporations' excessive monopoly power (Sivaramakrishna and Jyotishi 2008). Sharma (2014) found that contract farmers surveyed in Punjab, India, had no legal recourse for contractual disputes. The problem similarly exists in most of the world's developing regions. This could be circumvented using blockchain-based "smart contracts." Farmers could jointly participate in a decentralized blockchain network governing a smart contract that specifies conditions like price and expected output. The transaction would be verified across the blockchain and executed automatically if these conditions were met. Errant corporations could not withhold payment from farmers or arbitrarily reduce prices. Simultaneously, they would be assured that payment would only be made if the agreed terms were met. This democratizes the food supply chain and enhances farmers' income security.

Smart contracts are already utilized in the agricultural sector. Insurance providers like Arbol store real-time weather and pricing information on the blockchain, allowing farmers to enter transparent contracts without intermediaries (Xiong et al. 2020). By extending this to contract farming and other areas, governments could play a more indirect role in providing policy guidance, with the ability to monitor to ensure that farmers are offered fair terms with informed consent and impose sanctions and remedies when lapses are discovered.

Government support is vital

If used effectively, blockchain could be a game-changing solution for improving agrifood supply chain systems. However, as a nascent technology with an evolving security landscape, it will require more rigorous experimentation and testing by the private sector, the academic community, and government organizations. Therefore, it is crucial for governments to increase their participation in blockchain projects, especially given the widespread growth of internet access in Asia, to develop well-designed blockchain solutions for mass deployment to enhance regional food security.

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