BrandDataLab

BLOCKCHAIN IN FOOD & BEVERAGE TRACEABILITY

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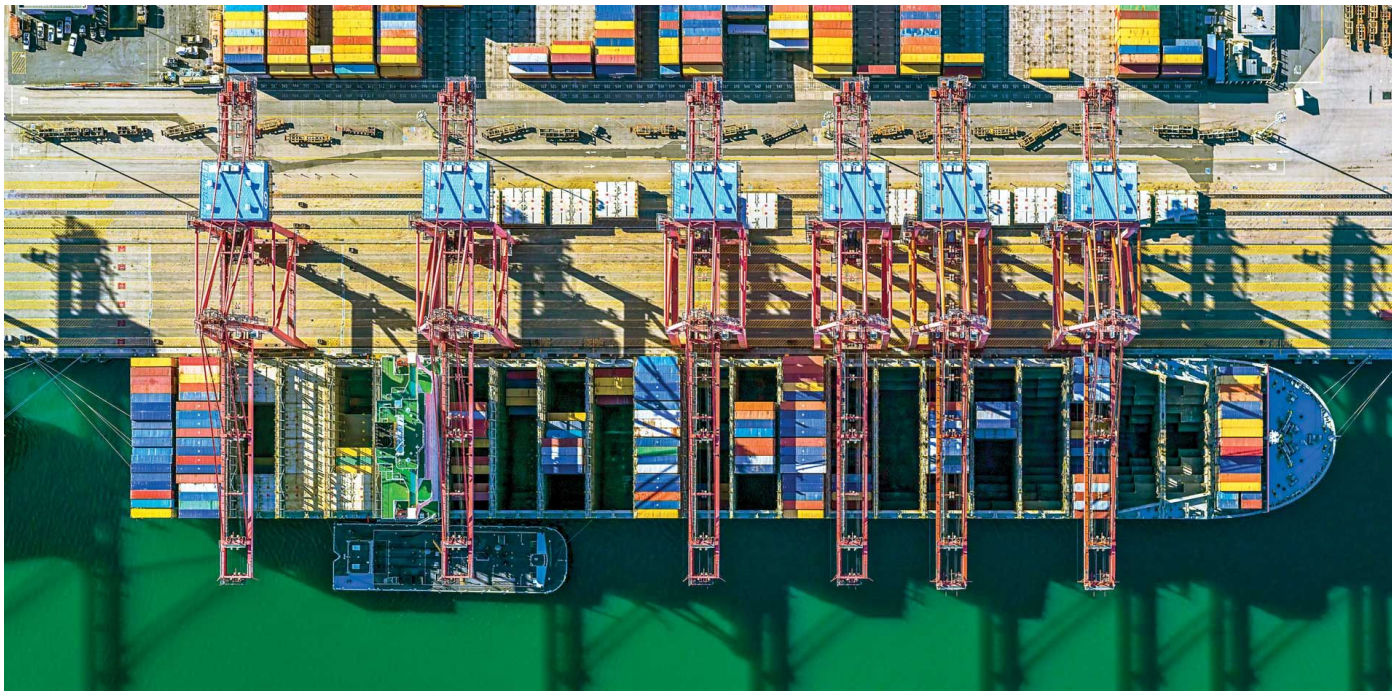
Executive Summary



"Every year, about 48 million people in the U.S. (1 in 6) get sick, 128,000 are hospitalized, and 3,000 die each year from foodborne diseases, according to recent data from the Centers for Disease Control and Prevention. This is a significant public health burden that is largely preventable (1)." Food Safety Modernization Act (FSMA). was signed into law on January 4, 2011 with the intent to bring sweeping changes to food safety (1). The New Era of Smarter Food Safety report was released by the FDA on January 27, 2022 that represents a new approach to food safety, leveraging technology and other tools to create a safer and more digital, traceable food system. "This New Era of Smarter Food Safety is people-led, FSMA-based and technology-enabled. FSMA created a risk-based, prevention-oriented regulatory framework (2)." The New Era of Smarter Food Safety created a blueprint to leverage the use of new and emerging technologies in data extraction, integration, and artificial intelligence analyses for safer and more traceable systems.

This white paper connects the dots for the reader between the universe of food and beverage supply chain, and the rapidly evolving universe of blockchain. The purpose of this paper is to provide the reader with working knowledge of the advances in blockchain, and their potential opportunities in adapting for the traceability in the food and beverage industry.

Tech-enabled traceability and outbreak response

"The records involved in moving food through the supply chain are still largely paper-based. This creates a system in which it is necessary to take one step forward to identify where the food has gone and one step back to identify the previous source. This, along with insufficient data identifying the product along the supply chain, creates an inability to rapidly track and trace food. During an outbreak, this can cost lives, millions of dollars in avoidable product loss, and damage to consumer trust. As has been seen with outbreaks in fresh leafy greens and other foods over the past decade, anonymity and lack of traceability in the food system are an Achilles heel that hinders more significant progress in rapid traceback efforts to identify contaminated foods. It also stands in the way of the transparency needed to better understand the supply chain in the event of public health crises. Advances in traceability to help protect consumers from contaminated products by doing rapid tracebacks, identifying specific sources and helping to remove products from the marketplace as quickly as possible when necessary (2)."

"The first step is data collection using FSMA Section 204 rulemaking to harmonize the key data elements and critical tracking events needed for enhanced traceability. Establishing this foundation for traceability will allow stakeholders in the supply chain to adopt and leverage digitally-enabled technologies, enable data sharing, and introduce approaches that greatly reduce the time it takes to identify the origin of a contaminated food tied to a recall and/ or outbreak. This will also create the transparency needed to anticipate and help prevent supply chain disruptions in a public health emergency, such as a pandemic. Ultimately, an end-to-end traceability throughout the food safety system is desired. Exploration of ways to encourage firms to voluntarily adopt tracing technologies and ways to harmonize tracing activities, which will support interoperability across a variety of technology solutions, working towards outcomes that are achievable for all sectors. With better traceback, the ability to conduct root-cause analyses will be greater, and findings from this work can be used to better inform the prevention-based framework that FSMA established (2)."

Aspects that can be integrated

"To fully realize a preventive controls system that rapidly incorporates new knowledge, it is important to ask how we can make processes and communications more effective, efficient, and in some cases, simpler. This will be particularly valuable in our collaborations with the public and private sectors to mitigate the risks presented by foods that are especially vulnerable to contamination. As more data streams and tools for rapidly analyzing data become available, we should also think about how we can best use predictive analytics tools to identify when and where contamination might be likely to occur, to prevent contaminated products from entering the food supply, and target efforts to remove potentially contaminated products from the market. It's also important for us to work with others in new and creative ways, such as leveraging reliable third-party audits and the expertise of our state and local regulatory partners to advance food safety (2)."

We must also have alternate approaches when traditional methods cannot be carried out during a public health crisis. Here are some of the key aspects of data related advances that can be integrated into the food and beverage industry.

- Advance predictive analytics capabilities through expanded use of artificial intelligence and machine learning tools.
- Increase the amount and quality of data through mechanisms that include expanded use of information-sharing agreements with regulatory and public health partners, academic institutions, industry and others.
- Explore methods to create public-private "data trusts," a bank of large volumes of data generated by industry that can be accessed for analytical work to further strengthen preventive approaches based on blockchain.

Blockchain overview and landscape

The blockchain concept came into being with Bitcoin's white paper (3) published on Oct 31, 2008. While Bitcoin is the leading cryptocurrency (4) and first known application of blockchain, the broader landscape has seen tremendous interest due to the various problem areas blockchain can help address due to its technical uniqueness.

Each area of cryptography, game theory, and distributed computing has seen many applications in the past. For the first time, the Bitcoin whitepaper demonstrated a novel way to combine them and address a specific problem called the Byzantine Generals Problem (5). This problem describes decentralized parties' difficulty in arriving at a consensus without relying on a trusted central party. Blockchain is a crucial structure as a part of this solution.

Blockchain, at its core, is a distributed ledger technology that operates in a decentralized manner. This approach contrasts with a centralization where a specific individual or a set of individuals control the approval of transactions. Blockchain creates a layer of trust to enable decision-making in a decentralized system without needing permission from any individual.

Core features of blockchain technology

Immutability

Each block in a Blockchain network contains an identifier called a hash value that cannot change once the block is added to the blockchain. Any network member can verify the transactions in each block for authenticity.

Decentralization

Decentralization allows a distributed network to control the decision-making. This helps in data reconciliation where every party has access to a real-time view of the ledger. Moreover, decentralization reduces the likelihood of systemic failures by eliminating reliance on certain computing nodes.

Security

Blockchain networks use some of the most sophisticated cryptographic techniques to make the network resistant to attacks. Each block has its own unique "hash value" calculated using a mathematical function.

Consensus

Blockchain networks rely on the consensus mechanism to validate and secure transactions. Consensus protocols are the algorithms that help the members of a Blockchain network reach a consensus about the state of the distributed ledger. Proof of Work, Proof of Stake and Proof of History are the most commonly used consensus protocols.

Trustlessness

In a blockchain network, every node has an identical copy of the data. If a member tries to alter the data and add it back to the distributed ledger, it will be rejected by the majority of the nodes in the network. This allows creating a trustless environment in which one network member does not have to know or trust anyone else.

Throughout the history of technology, certain foundational paradigms have emerged upon which innovative ecosystems have been built. Inventions such as the internal combustion engine, semiconductor, and the personal computer are examples.

The internet protocol suite, commonly known as the TCP/IP model, was a foundational technology invented in the early 1970s by the US Department of Defense. TCP/IP laid the groundwork for the modern internet, adding trillions of dollars to the global economy (6). Analogically, blockchain can be likened to the early days of TCP/IP, where specific applications such as cryptocurrencies have come to fruition. The latent potential is much more enormous and is already being realized in tangible form.

Key opportunities for blockchain for branded products and retailers

This section would like to give the reader an overview of the branded products' supply chain challenges and shed light on blockchain's ability to tackle some of these issues.

Branded products rely on a supply chain mechanism consisting of a series of steps to get the finished products in the hands of the consumers. These steps involve producers, vendors, warehouses, transportation, and retailers spread globally. They usually span across various product development departments, marketing, operations, distribution, finance, legal, and customer service. There is enormous complexity involved to get a product in the hands of consumers efficiently while adhering to high ethical standards.

Not only is the supply chain ecosystem vast, but its activities are also quite complicated (7). Procurement orders, distribution entries, shipment orders, and payments may not sync up neatly. There is a many-to-many relationship between orders and corresponding shipments. An order can be divided into multiple shipments, and conversely, a single load can account for numerous orders.

There are several touchpoints throughout the supply chain ecosystem where things might go wrong and they often do. Mistakes such as invalid inventory data, incorrect labels, missing shipments, and duplicate payments are not uncommon. Trying to locate the source of the error and fixing it is time-consuming and greatly expensive after the fact. If a poor quality or counterfeit product gets in the hands of consumers, retailers have to bear the brunt of the dissatisfaction heavily. Food fraud is a massive issue faced by many countries. Cases of adulteration have increased by 30%, while counterfeit incidents have grown by 47%, according to Food Authenticity Network (8).

Let us look at the solutions and approaches that exist to mitigate these concerns and improve overall effectiveness, especially traceability of a supply chain. The following is an overview of some legacy systems, their pertinent aspects, and their limitations.

We will discuss audits, inventory and warehouse management systems (IMS & WMS), and Enterprise Resource Planning (ERP) implementations all of which form the backbone of supply chain management.

Audits

One of the procedural mainstays in any organization is periodic audits performed manually.

An audit is usually a comprehensive multi-step process that helps determine whether the systems and processes within an organization are following the operating guidelines.

They are generally effective for compliance contracts that are well defined. However, they fall short when it comes to setting preventive or diagnostic protocols that can aid in overcoming operational shortcomings. Identifying areas to audit to a detailed and granular level can be challenging. Furthermore, coming up with a standardized results framework and actionable recommendations to communicate to the senior management is non-trivial. Planning an external audit is an incredibly challenging endeavor when done across multiple operational entities such as suppliers, vendors, and third-party actors.

Inventory and Warehouse Management Systems

An inventory management system (IMS) is a set of processes implemented Using software, hardware such as RFID barcode scanners with asset tags, and procedures to monitor and track the stocked products.

Two top ways to manage inventory are periodic and perpetual systems. While the goal with both systems remains to provide a predictable flow of inventory, there are limitations to each.

With a periodic inventory system, there is the risk of stockouts or overstocking since the inventory count is run only at the end of a defined period. Whereas with a perpetual system, there is overdependence on human entry. The system can lack real-time information about stolen, spoiled, or damaged units until the company initiates a manual check.

Warehouse management system (WMS) is similar in framework to IMS, and businesses use it for managing stock activities in a warehouse setting. It involves tracking movements with a focus on picking and shipping stock. WMS is also typically used for fulfillment and replenishing. WMS comes with its complexities when it comes to managing at scale. Automation is not always possible, and it needs manual intervention from someone with expert knowledge.

Enterprise Resource Planning (ERP)

As seen above, using IMS and WMS as standalone solutions present challenges even though they help resolve specific issues within the supply chain.

An ERP implementation brings together a holistic view of the activities across the business. Modern supply chain management uses ERP by integrating IMS and WMS described above. ERP is useful for automating the data flow between different business applications via a software platform (9). It can help better project management, budgeting, and forecasting if implemented correctly.

However, implementing an ERP system for the supply chain is not a foolproof process, and it relies on several things to happen correctly. For example, cross-organizational implementation lends itself to multiple touchpoints where data capture can creep in inaccuracies.
Even though the contemporary supply chain ERP systems are software-based, these are extremely complex systems that can result in costly overruns, security breaches, and data access challenges. Gartner has estimated that 55% to 75% of all ERP initiatives fail to meet expectations (10).

Blockchain in the supply chain for branded products

As we have seen, the supply chain is fraught with not easily addressable issues. Let us look at how blockchain technology, when used alongside these existing solutions, can play a more significant role in bringing increased transparency, traceability, and efficiency to the supply chain. With the characteristics of blockchain, such as immutability, security, and trustlessness, as discussed in detail in section 3, it becomes clear that businesses can improve their supply chain management through blockchain-driven end-to-end tracking.

As per research by the Food Industry Association and NielsenIQ, 72% of the shoppers (11) said that transparency was either important or extremely important when deciding which food brands and retailers to support [9]. Blockchain allows to digitize the physical assets and create a decentralized record of all assets from production to delivery, making it entirely transparent for businesses and consumers.

Every ingredient in a finished product from each subcontractor in the supply chain can be tracked, reducing chances for counterfeits and possible fraud. Especially with perishable food, the food industry is highly vulnerable to making mistakes, and traceability is critical. The immutable nature of blockchain ensures that every player in the food supply chain records the data and events in a tamper-proof way. The entire journey of a food product from farm to table can be monitored in real-time. When an unforeseen event such as a foodborne illness occurs, the root cause analysis becomes easy by pinpointing the source of contamination.

Blockchain in the supply chain for branded products

Using blockchain, businesses can monitor the supply chain data in near real-time, thus making an effective audit possible. The reporting on top of the blockchain can accelerate the usually slow manual checks for compliance and administrative tasks.

The stakes for the reputation of a business are high in this age of social media. Blockchain has a unique capability of public verification of any entry for authenticity. Companies can provide a controlled software user interface via Application Programming Interfaces (APIs) to the general public concerning food traceability. Doing so can help garner trust from the everyday consumers and enable the businesses to stay ahead of the curve in creating a PR-friendly image.

Blockchain can deliver more than just traceability and transparency. It can help in balancing the market pricing scenarios as well. The legacy system of pricing framework relies on judgments of individual players rather than the data points gathered from the entire supply chain. The ledger entries of the recorded transactions that are shareable in a secure manner can help create a holistic overview of the market supply and demand.

We hope by now it is amply clear to the reader that the potential for using blockchain-based solutions in the branded product supply chain is enormous. The following section will look at technical details on end-to-end blockchain implementations with some use cases.

Basic blockchain architectural and technical pathways

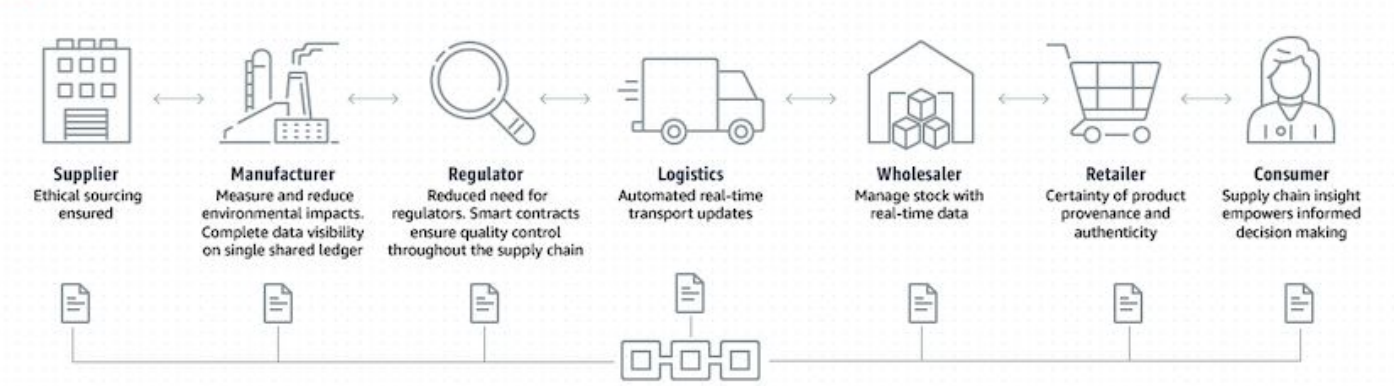


Figure 1. Supply chain on blockchain

This section will look at concrete examples of blockchain software implementation using Amazon Web Services (12), the leading cloud platform.

Figure 1. shows a track and trace solution wherein the supply chain can benefit from end-to-end visibility using a blockchain implementation. We describe some examples of direct benefits below.

The suppliers have to meet stringent requirements of ethical guidelines, which are made more accessible through the visibility of data on the blockchain. The manufacturers can look at the blockchain data for any impact on the environment.

The job of regulators is made much easier since they can collate the data points from across the supply chain from a single ledger to audit. Moreover, there is assurance that each transaction recorded by each party is cryptographically secure and immutable.

The feature of real-time access to data allows logistics to track the shipments, wholesalers to manage stock efficiently, and retailers to identify the source of contamination instantly. The consumer can make informed decisions based on the known provenance of the products.

Combining blockchain technology with smart-technology like the Internet of Things (IoT), supply chains can precisely automate production, distribution, and quality control.

Basic blockchain architectural and technical pathways

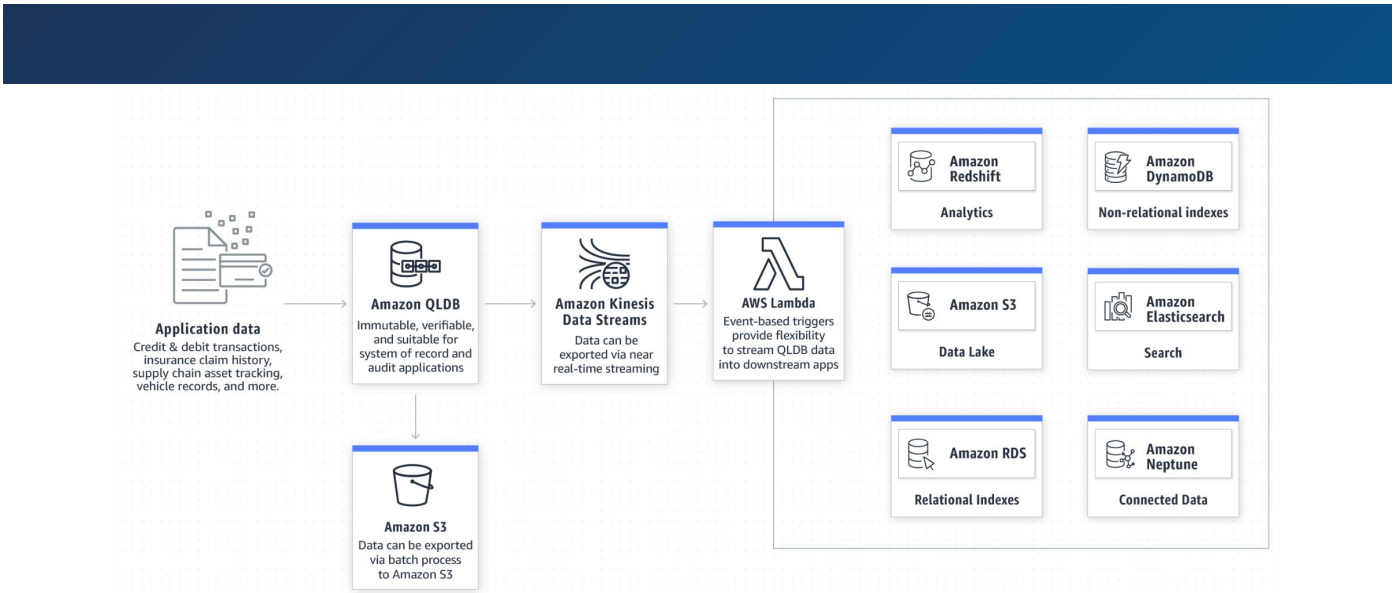


Figure 2. AWS Cloud implementation of a blockchain

Figure 2 captures the technical implementation of a blockchain based supply chain solution hosted on the AWS cloud.

The networks of a supply chain feed the application data to the blockchain's shared ledger, providing total data visibility and a single source of truth.

Amazon QLDB is a fully managed ledger database that provides a centralized, immutable, and cryptographically verifiable transaction log. It is well suited to use in a supply chain environment since a trusted authority owns and manages the ledger and shares it with any number of parties working together.

Data storage components such as Amazon S3 and DynamoDB provide persistence capabilities in different data formats. Real-time streaming of data is possible due to Kinesis which can trigger events further handled by the AWS Lambda component.

Companies can build a myriad of applications on top of this infrastructure. Elasticsearch service allows searching for any data points in the ledger. The prediction analytics dashboard built using Amazon Quicksight can show any visibility gaps and inaccurate supply and demand.

Amazon S3, API Gateway, and AWS Amplify allow web and mobile applications to consume information from the blockchain data through APIs, while relational databases built using Amazon RDS technology allow structured data storage.

What can BDL do for you?

Whether the food and beverage industry is prepared or not, traceability using blockchain technology is bound to be ubiquitous. It is imperative that each organization lay its internal groundwork and be ready for the adaptation of the blockchain technology. A team with the right blend of food scientists, supply chain experts, regulatory analysts, data scientists, and blockchain experts, is required for effective application of blockchain technology in food and beverage supply chain, Brand Data Lab, Inc. is a boutique strategic advisory firm that is focused in helping clients with their data extraction, integration, and AI/ML analyses needs. BDL has the necessary expertise to develop your firm's blockchain technology roadmap and implement it.

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