

When Blockchain Meets IoT:

Ensuring Food Safety in the 2020s

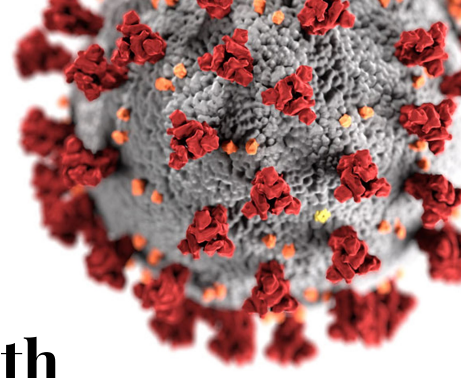


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Editorial

Behavioral Changes in the Aftermath of COVID19 Brings Higher Demand in Safe and Traceable Food on Ecommerce Platform

Despite the highly contagious nature of COVID19, food safety isn't directly threatened, as the FDA¹ has stated that foodborne exposure is not a viable means of transmission. However, the impact on the food supply chain will be felt by the immediate and lasting changes in consumer shopping preferences.

Statistical evidence of affected consumer behavior:

For the period of Jan. 1 through March 15, online and BOPIS (buy online, pick up in-store) sales of food jumped 61.3% and the number of orders rose 57.6%, compared with 2019 in the US².

Chinese food e-commerce sites noted a 45% increase in daily active users in the period after the Chinese New Year compared to before it³.

The increase in digital shopping across all age ranges will have a few key impacts:

○ Increase in SKUs

E-commerce retailers will sell low volumes across a higher range of products rather than high volumes of a reduced-SKU offering in physical stores. Specialty food offerings will be able to take market share from more established brands if they can ensure their customers with food safety and quality.

○ Increasing trust in online markets

Buyer trust in local markets regarding freshness, quality, and taste will be challenged by online platforms whose product mix is more responsive to customer demand. Coordinated and agile supply chains that can be responsive to changing demand can gain market share regardless of geographic retail presence.

○ Increasing preference for health and safety over price and utility

COVID19 also raises public awareness of health and safety in general. The convenience of online shopping exposes consumers to more online platform options and therefore are able to find products that better fit their demand.

All three of these shifts are contingent on the manufacturer's ability to provide safe and traceable products with uninterrupted supply chains. A trust shift from brands to individual products will force producers and retailers that previously relied on brand recognition to offer more visibility into production processes, the supply chain, and food safety standards. Growing demand for online food shopping will make the industry more profitable for bad actors, encouraging eCommerce sites to improve the visibility of their products and suppliers. Platforms and brands that adopt the blockchain and IoT technologies discussed later in this report can create notable improvements in transparency and customer loyalty.

Executive summary

Low food safety standards pose a risk to governments, consumers, and the food producers themselves. Government regulators are unable to halt the flow of counterfeit and low-quality goods exploiting the profitability of global food markets. Digitalization has the potential to solve this through the implementation of IoT and blockchain solutions that enhance visibility and accountability in food production.

We identified five major areas of transformation for the decade:

- **Changing the mindset of stakeholders** — Enterprises must support government regulators in initiating change.
- **Digitalization in production** — Technology has the potential to increase crop yields and production efficiency.
- **Safety in processing** — Transparency can clarify the contents of food products and packaging.
- **Optimized supply chains** — Stakeholder coordination can reduce spoilage and contamination.
- **Social and environmental preservation** — CSR and sustainable initiatives are aligning the goals of stakeholders worldwide.

Key Findings:

- IoT & blockchain platforms can increase trust, transparency and coordination throughout the food supply chain, **resulting in \$155 billion** per year in potential savings.
- Better traceability will boost the international food trade by **over \$100 million per year**.
- IoT & blockchain solutions can create **up to \$47 billion per year** in revenue enhancement.

The food safety problem

Food safety is one of the billion-dollar global problems currently left unaddressed

The food value chain is an \$8.1 trillion industry, encompassing a variety of stakeholders — producers, processors, distributors, consumers and regulators — acting as an extremely complicated nonlinear system, totally opposite from the simplified ‘from farm to fork’ concept that is usually represented. Moreover, on average every food product travels over 40,000 miles⁴, which further exacerbates the vulnerabilities resulting from the lack of traceability and visibility.

200+ diseases

are caused by unsafe food containing harmful bacteria, viruses, parasites or chemical substances⁵

600 million

people fall ill after eating contaminated food and 420 000 die every year⁶

40%

of the foodborne disease burden are carried by children under 5 years, with 125,000 deaths every year⁷

A food safety incident is any situation within the food supply chain where there is a risk, potential risk, perceived risk of illness, or confirmed illness associated with the consumption of food⁸.

Regardless of the formal definition of the problem, for every extra day it is left unaddressed, businesses face billions of dollars in potential legal and reputational risks as well as the possibility of costly recalls. Consumers are exposed to serious health threats, including food contamination, allergies and even death, and governments lack control levers in case of a disease breakout.

The 2013 horsemeat scandal in Europe illustrates how serious the financial consequences of food safety incidents can be. The incident affected leading supermarket chains including Tesco, Lidl, and Aldi, which had to withdraw beef products costing millions of dollars. It also resulted in changing consumers’ shopping habits, as they began opting for less processed meat. Moreover, the EU governments were forced to fundamentally revise relevant food laws and introduce stricter testing practices, affecting the whole industry.

Quantifying the food safety cost

Understanding the effect food safety incidents have around the world

Food Safety in the United States

In the United States, there is a ~1% chance a food safety incident could happen and on average there would be a ~30 – 65% of value loss due to these food safety incidents — resulting in around \$48 billion a year⁹. This \$48 billion value loss includes on average \$20,000 in regulatory fines per person impacted, more than \$1.5 million of inventory loss per incident, and \$10 million due to loss of reputation. The estimated cost of food safety problems, including loss of economic activity due to inability to work or medical costs and death in the US, has increased by 20% y-o-y for the last 4 years and has reached \$56 – \$93 billion a year¹⁰.

In 2018, Chipotle — a famous fast food restaurant chain — suffered from a food safety incident in which 832 people were impacted. It cost \$25 million to settle the event and sent the stock price of the burrito chain down by as much as 9% as a result. More severe punishment was handed down for Chi-Chi's restaurant chain in the 2000's — the restaurant lost more than \$13 million in lawsuits and was forced to file for bankruptcy¹¹.

Food safety problems are an important issue that a company should never ignore. Companies facing food safety problems could encounter heavy regulatory fines, lawsuits, severe product recalls, and major losses in market value due to the media attention and loss of reputation.

Food Safety in the Rest of the World

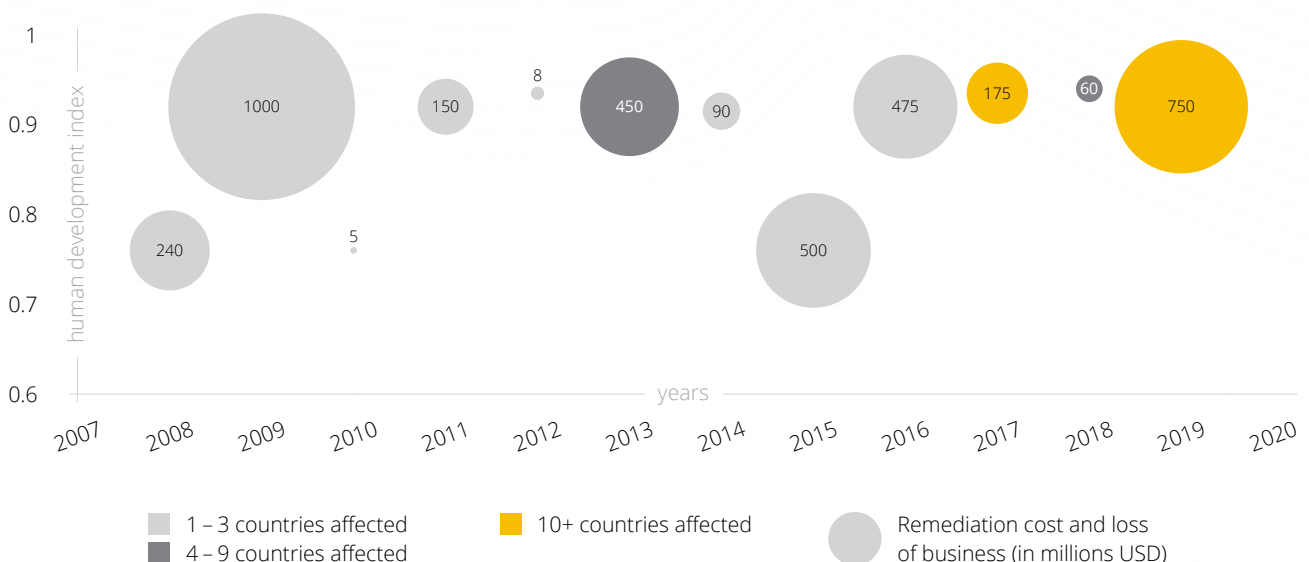
To the developing world, where regulation and fines may be less strictly imposed, food safety is also costing lives and losses in productivity. Overall, unsafe food costs lower and middle-income economies \$110 billion in lost productivity and medical expenses each year¹².

Less developed countries are most vulnerable to food safety problems due to the lack of transparency in their supply chains and low regulatory control. Moreover, many farmers in these countries neglect food safety measures which leads to severe problems. Relative to their population, low- and middle-income countries in South Asia, Southeast Asia, and sub-Saharan

Africa account for 41% of the global population yet 53% of all foodborne illness and 75% of related deaths¹³.

Developed countries have also had recent struggles with food safety. Over the past 12 years, the biggest food safety scandals happened in countries scoring high on the Human Development Index. Due to an increase in global trade activity, the scale of food safety problems has grown: firstly, the number of countries affected by each incident goes up, secondly, the total losses from scandals that occurred in 2014 – 2019 exceed the losses in the five years preceding that. Clearly, food safety is a global issue and as a result all countries have a responsibility in prioritizing efforts to improve this area.

Major food safety incidents happen nearly every year and aren't limited to underdeveloped countries



2008 — Milk scandal, China¹⁴

2009 — Peanut butter scandal, USA¹⁵

2010 — Contaminated green beans scandal, China¹⁶

2011 — Listeriosis outbreak, USA¹⁷

2012 — Salmonella outbreak, Netherlands¹⁸

2013 — Horsemeat scandal, Europe¹⁹

2014 — McDonald's meat scandal, Asia²⁰

2015 — Rotten frozen meat, China²¹

2016 — Chipotle foodborne illness, USA²²

2017 — Fipronil egg scandal, Europe and Asia²³

2018 — Listeria outbreak, Australia²⁴

2019 — Salmonella-infected chickens, Brasil²⁵

Government Responses

How regulation is implemented to drive higher safety standards

Regulatory bodies are taking action to combat the food safety problem, but decisive results have yet to materialize. In the US, the Food Safety Modernization Act (FSMA) was passed in 2015. It aims at food certification, supply chain traceability and transparency. A key part of the act is increasing the digitalization of supply chains and encouraging participants to be more innovative. Since then, the number of major food incidents has decreased by 47%, part of which can be contributed to the realization of FSMA²⁶.

In China, a new Food Safety Law (passed in 2015) has been the main preventive measure from the food safety problem. To 2019, more than 15 million individual inspections were conducted

annually and 500,000 food violations were uncovered leading to confiscation of \$2 billion worth of contaminated food, counterfeit food items, and mislabeled products²⁷.

In Europe, a General Food Law was passed in 2002 to protect the customer's right to a higher standard of food safety. An integrated approach to food safety 'from farm to fork' was developed. More than 5 million euros were saved annually since 2005 by this one time action, but food safety problems occur from year to year leading to 35,000 incidents every year since 2010²⁸.

To summarize, the governments around the world have been pushing businesses to take action through legislation, but have failed to stop the problem altogether. Companies must confront and comply in order to combat the food safety problem. **A good course of action for governments would be to build and maintain adequate food systems and infrastructures, thereby fostering multi-sectoral collaboration between different participants of the food supply chain.**

Unsolved food safety issues

Despite all these efforts, food safety will remain problematic because it is profitable for bad actors. It is impossible to give an exact value of the lucrative fraudulent food market, yet to the right are some figures that demonstrate the scale and profitability of the industry.

\$375 million

value of hard Italian cheeses in the US intentionally mislabeled by producers²⁹

25–70%

of red snapper, wild salmon, and Atlantic cod are disguised by species that are less desirable, cheaper or more readily available³⁰

50–60%

of 110 kinds of commercially available honey in the US market might be adulterated with sugar from beets, corn or rice to save money³¹

150,000

litres of fake olive oil were seized by German authorities in 2019, with counterfeit oil producing in 8 million euros in yearly profit for the suspects³²

20%

of global wine sales, a \$30 billion industry, are suspected to be counterfeit³³

Food safety challenges in 2020

Some societal challenges will evolve in the next decade, putting more pressure on world governments to leverage technology in an effort to adapt

World's population growth

Resource scarcity. According to estimates by the Food and Agriculture Organization of the United Nations (FAO), farmers will have to sustainably increase their yields by about 50% by the year 2050 in order to feed everyone³⁴. If this fails to be achieved, the rapid population growth, especially in developing countries, would result in people forced to eat low-quality or even contaminated food.

Rise of population density. Ever-increasing population density means that an outbreak caused by poor food safety standards could lead to a significant excess of the number of infected people over initially ill ones.

Comprehensive centralization

Urbanization. With more and more people moving to live in cities, the number of cafes, restaurants and fast food points ramp up quickly following the growing demand. Many of them are not preparing food in appropriate conditions so the risk of food poisoning can be frighteningly high.

Multinational and domestic corporations. Huge packaged goods companies are becoming more widespread, and therein lies a danger. Bulk distribution of products increases the risk of mass food poisoning.

Biological Threats

Emerging bacteria and antibiotic resistance. Antibiotics could struggle to cope with new strains of bacteria. Controls are needed to reduce the misuse of current antibiotics in the food supply chain.

Zoonotic Diseases. Farms and markets put animals and people in close proximity, providing a breeding ground for zoonotic diseases such as SARS, H1N1, H7N9, and the COVID-19 outbreak. 75% of new pathogens over the last four decades have originated in animals³⁵. Supply chain visibility is needed to reduce the unregulated sales of livestock and other animals that lead to devastating illness affecting human life and the global economy.

Food Safety landscape changes in the 2020s

**In the upcoming decade,
a number of technological
breakthroughs are
bringing changes to the
food safety landscape**

Industry 4.0 is confidently transforming the landscape of various businesses all over the world bringing greater efficiency, as well as taking control over processes that could not be managed ever before. Food industry companies are no exception, as they could notably benefit from the adoption of new technologies.

Seeking transparency, traceability and trust, the food industry faces a growing demand for safety that could stand as a major driver in changing standards in the next decade. Although the transition from difficult and time-consuming manual tracing processes won't be instantaneous, the potential results should spur companies to embrace the new standards.

IoT and blockchain will be a major part of these changes, as automation and traceability reduce human interference with the food supply, shrinking the trust gap between producer and consumer.

This section identifies five key areas undergoing transformation:



Stakeholder
Mindset



Food
Production



Food
Processing



Supply
Chain



Global
Trade

Changes:

Stakeholder mindset

While governments clearly have a role to play in regulating and facilitating food safety, members of the food value chain are likeliest to have the most impact on solving the problems

The food value chain is the network of stakeholders involved in growing, processing, and selling the food that consumers eat — from farm to fork.

As actions taken by governments are not enough to prevent bad actors and oversights that lead to damaging incidents, building confidence in food safety in the 2020s requires collaboration amongst all the participants in the food value chain. Moreover, to see a significant increase in food safety in the next decade, **every process has to move towards transparency, traceability, and trust.**

Stakeholders have the following incentives to implement additional technologies:

- Reduce losses
- Prevent fines
- Access new markets
- Increase supply chain coordination
- Improve brand reputation

Mitigating food contamination and spoilage risks not only benefits the health and nutritional needs of end consumers, economic benefits for regulators and in turn, adds millions of dollars in revenue for food brands and companies.

Changes:

Food production

Digitalization in food production

Leveraging IoT technology will be the major driver of enhancing safety in agriculture, farming and seafood production in the next decade

Nowadays, food production has the lowest level of digitalization of any industry³⁶, so enhancement through IoT technology could dramatically change the rates of growth in the forthcoming years primarily due to the low base effect. Additionally, digitalization requires multiple parallel advancements to rebuild existing systems to ensure safety of production processes.

Chasing the chance to boost productivity, food producers will follow the trends of ubiquitous

connectivity and data mindset. According to a survey by BCG, three-quarters of executives cited technology that fosters data-enabled agriculture as a top investment priority³⁷. We expect IoT, blockchain technology, machine learning and robotics to be the pillars of the industry 4.0 revolution and shape the future of the agriculture industry.

There are **three main ways** in which IoT would affect food production in the 2020s:

- 1 Implementing Industry 4.0 technologies to improve **functional excellence in productivity growth and costs reduction**.
- 2 Digital developments leading to the creation of **digital business models** through which all of the value chain participants unlock new benefits.
- 3 As a result of the first 2 ways, the potential of new instruments would affect **demand patterns in end markets**.

Productivity gains and efficiencies through IoT could dramatically impact yields in the forthcoming years

Benefits

of digital transformation

Impact

on food production

Comprehensive monitoring

Sensor technology — embedded in IoT devices — will become more cost-effective and more widely available. Implementation of systems that exploit the IoT devices to fetch data about hundreds of factors will significantly influence the food production process.

This advancement will make large-scale monitoring and detection possible. Precise information about every step in the food production process, more informed and speedier decisions, reduced harvest failures and more effective cost accounting in the current period as well as predicting the problems that can entail additional costs.

Field for experiments

Growing number of IoT devices that serve the needs of agribusiness will help embrace real-time and historical data to combine it with machine learning.

Farmers will be able to simulate experiments and measure the results virtually, systematically optimizing the performance without risking any crop yield.

The new workforce

Unable to obtain all the workers necessary for production, farmers will combat labor shortages by adopting robots, drones, electrified systems and autonomous equipment.

Automated or robotic systems will eliminate manual work or enhance speed, consistency, and capacity. The new workforce will augment operations such as pruning, thinning, and harvesting, as well as mowing, spraying, and weed removal in order to reduce labor shortage in the food production industry.

Marketplaces

The rise of digital platforms is likely to influence the development of food production in the 2020s as the industry is rapidly entering the era of platform economy. Platforms will create new avenues for both SMEs and large enterprises.

The variety of marketplaces will assist food producers: from the ones designed for purchasing necessary seeds, fertilizers, crop protection, renting or leasing equipment, to the ones that help producers excluded from global trade in expanding to new geographies. Moreover, ubiquitous marketplaces result in greater price transparency for the products, resulting in more efficient businesses.

Benefits

of digital transformation

Impact

on food production

New business models

Software-as-a-Service business models

Growing level of digitization in the food production industry will be largely determined by SaaS vendors. Lack of internal capabilities and wide potential of digital technology applications make the food production industry an attractive market for companies that provide solutions for smart agriculture and farming.

SaaS business models called to the spotlight to meet demands of the transforming food industry will bring drastic changes to business processes. Applications such as crop monitoring based on IoT or farm performance analysis can thus shift the industry from low efficiency towards a new level of productivity enhancement.

Change in the end markets

Decreasing suspicions

The combination of IoT and blockchain technologies will become the basics for industry bodies ensuring provenance and quality of products in 2020s. On the other side, the demand for confidence in quality of the products is disrupting the food industry over the last few years.

Food producers and other members of the food value chain would get a brilliant opportunity to break the distrust barrier among the end consumers. Meanwhile, the emergence of more solutions could further strengthen food production quality control.

Boosting customer loyalty

Redefining expectations of high standards for vegan-friendly, antibiotic-free, halal, gluten-free and other specialty products requires transparency from food producers.

Food value chain members could capitalize on unique competitive offers provided by transparency. Unique user experience including learning about the product and plunging into the production process would help to gain customers' attention and then build and retain trustful relationships.

According to Cointelegraph Consulting market analysis, the value of the IoT market in worldwide food production is expected to grow from \$14 billion in 2020 to \$25 billion by 2025 at a CAGR of 12%.

Key areas to ensure food safety

Food producers are tasked with great responsibility to ensure food safety for their part in the value chain



Efficient use of data: To achieve the best result possible in the field of food safety, it is crucial for food producers to embrace a data-driven mindset. The most serious barrier companies have to overcome on their way to a transparent and trustful digital system will be the shift in the way they perceive data. An essential element of food safety, information will have to be collected, stored and managed in a digital format to provide actionable insights for the companies, their partners and consumers.

Real-time monitoring of food production conditions: Increasing food safety with the help of IoT technology is a reliable way to detect and prevent batches of contaminated products from transferring along the value chain. Whether it is vegetables infected with mold or oysters contaminated due to water quality, the digital system will enable the producers to monitor, contain, and seize the spoiled products.

Strict control of chemical use: Difficulty setting standards for fertilizers and crop protection chemicals requires government regulation and the help of the some new technologies. Closely monitoring the state of crops can help to eliminate the risk of excessive use of chemicals.

Changes:

Food processing

Technology provides more control of the production process, creating more opportunities to improve visibility in the supply chain



Digitalization in food processing, manufacturing and packaging

Computer-based modelling of the packaging design. Modern technologies allow for the modelling of the packaging with all the cutouts and details. After the design process, stress simulation of the packaging is performed in order to find potential problems and evaluate angles and bend points. The result is robust, good-looking and safe packaging that effectively protects the product from damage.

Virtual prototyping. Computer software helps to create a consistent mixing solution and a receipt for the product based on desired qualities. It is also possible to select container and mixer forms, render and calculate blending times, and finally choose the parameters for the optimal manufacturing process.

Totally integrated automation. Fully automatic control of the manufacturing process enables efficient and safe production. Quality checks can also be included in the production steps in order to receive immediate feedback in case the quality is below the required threshold.

Food processing challenges for the 2020s

Business environments will face several major changes in 2020 that will be revolving around consumers wishing to take care of their health and environment



Regulation on plastic use. Eco-friendliness has already become a major trend across all industries and is likely to become even stronger in the next decade. In this case, a product that is labeled as 'eco-friendly' appeals to customers and is likely to accrue lucrative sales. Meanwhile, plastic is considered one of the most damaging materials and companies that abandon its use may get substantial support from consumers.

The rising concerns about product traceability. Consumers are demanding to know what exactly goes into their food and how ingredients were transformed into the end product. If an incident occurs, traceability allows for a prompt response, providing for diagnosis and mitigation of the problem thus increasing customer loyalty.

Futhermore, traceability will improve the ability of a country to legally enter export markets. According to Europol, more than €100 million worth of potentially dangerous food and drinks were seized in the latest Operation OPSON, a substantial amount of which were imported illegally³⁸. At the same time, 79% of Millennials like to experiment with products from different countries, making imported groceries a growing trend³⁹. Better traceability will boost the international food trade by over \$100 million per year in the near future.

The rise of health-consciousness among consumers. Consumers are increasingly health-conscious, so the demand for products that do not carry the "healthy" label is declining, and to stay at the top, the need to eliminate artificial constituents from products has come to the fore as one of the major challenges faced by food manufacturers.

Labelling. False labels put on a product might mislead consumers and result in lawsuits, damaging the producer's profit margins and reputation.

According to Robert Handfield (NC State University), 60% of recalls were due to labeling errors and packaging art⁴⁰.

Changes:

Supply chain

Digitization in food supply chains

The supply chain is a major vulnerability for food spoilage and contamination. Pairing IoT with blockchain technology could drastically change the situation over the next decade

The food industry is characterized by highly complex supply chains. Often times, thousands of kilometers separate the producer from the processor; while ingredients for one product may be sourced from diverse regions around the world. The number of intermediaries within the food supply chain are increased due to special requirements for transportation, such as temperature or humidity levels. Under such conditions, end-to-end visibility within the supply chain should be a top priority for businesses seeking to build trust with consumers.

Blockchain

Supply chain is clearly an area where blockchain will make a major impact. Blockchain has proven to be effective with supply chain processes such as tracking and tracing, cross-border payment processing, insurance, and paperless documentation.

By 2023, we expect blockchain to support tracking of 10% of the food industry products globally.

IoT

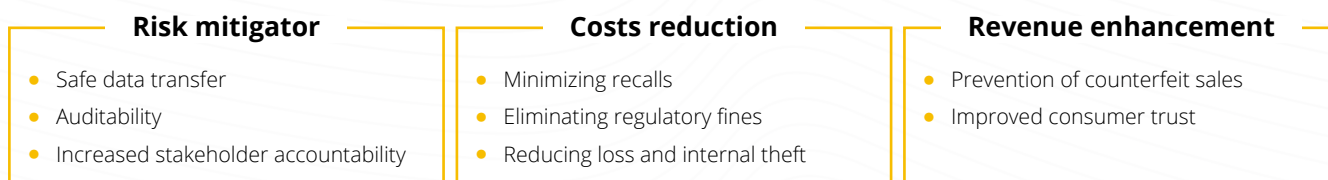
IoT technology is poised to make an impact in the upcoming decade. The IoT market was expected to hit \$745 billion in 2019, with investments reaching \$190 billion, including projects connected to supply chain solutions⁴¹. Moreover, Gartner forecasts enterprise and automotive IoT market Compound Annual Growth Rate (CAGR) to achieve 20%⁴².

There are IoT-related applications addressing the food safety problem for which blockchain is a perfect match. Real-time traceability could be achieved with the data from IoT devices that is shared through blockchain. This system provides visibility into the status of products and shipments and verification by all stakeholders across the value chain.

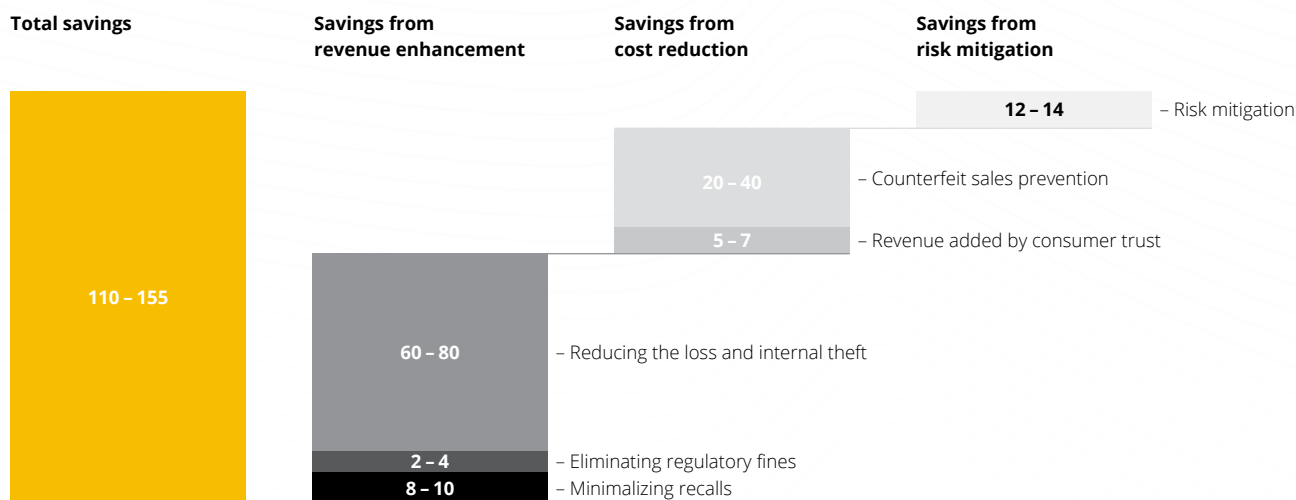
In the 2020s, we expect both IoT and blockchain technologies to overcome the technical and regulatory obstacles to become part of the standards established by governments and market players.

We estimate IoT+blockchain-based solutions can reduce annual costs by \$70 billion for the food industry globally and create up to \$47 billion in revenue enhancement. In addition, we expect solutions to reduce potential losses due to food safety risks by \$12 billion to \$14 billion.

There are **3 main ways** how IoT plus blockchain systems can add value in the food supply chain:



The potential improvement for food industry supply chains^{*}



^{*} figures in billions (USD) Sources: Statista^{43, 46}, Swiss Re⁴⁴, FSIS USDA⁴⁵, FAO⁴⁷, BCG⁴⁸, CBCnews⁴⁹, Deloitte⁵⁰

Challenges for supply chain

The potential of IoT and blockchain to increase food safety in the supply chain can be limited by diverse problems that require special approaches and active collaboration from food value chain members



Growing value chain length

More steps to consumer. Primary and secondary production, manufacturing, distribution and many more processes involving intermediaries would imply that the number of stages where food could be contaminated or spoilt also grows.

Investigating mistakes. The rising number of multiple parties separating the producer from end-market customers would make the task of finding the guilty stakeholder in case of food contamination much more difficult.



Capturing the essential data

Paper trails. Difficulties the food value chain members face accessing the essential data due to ineffective, issue-prone, and antiquated paper-based systems of record tracking will slow down the pace of food safety positive change. Until manual processes prone to errors and miscommunication are replaced with digital formats across the whole food value chain, growth of food safety levels will be inhibited.

Integrating stakeholders' systems. When building up a network of partners, companies will face an integration problem. Establishing technical and governance standards will be a key challenge for innovators, yet without a consensus, transparent data transfer will not be possible.



Climate change

Distribution risks. Increasing average temperatures makes it necessary to change food distribution and storage infrastructure to prevent premature food spoilage.

Key areas to ensure food safety in Supply Chains

The food value chain members can generate substantial benefits — including advanced efficiency, transparency and traceability — from adoption of technology for supply chain collaboration



Unifying the food value chain members' systems. Creating a single system for food traceability that unifies both safety requirements and the data flow. The food value chain members need to incorporate the required quality and food safety parameters into their contracts and bring the systems to the standard that fosters traceability.

Collaborating to build a trustful system. Greater supply chain visibility will increase trust within the food value chain. Every member could be confident about the quality of the goods transferred whether it is a food producer, processor, or distributor. The system would discover which stage the product was contaminated or spoiled, penalize the guilty party and allow retrieval of the products before they reach end consumers and cause an outbreak.

Changes:

Global trade and CSR

Being one of the key sectors of the global economy, the food industry is facing a severe transparency problem that needs to be resolved in the 2020s

The agriculture & food trade remains one of the few bright spots of the global economy:

\$2 trillion

industry⁵¹

6%

annual growth rate⁵²

\$300 billion

value of food products will be traced on blockchain by 2027

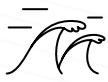
If the growth rate of the global food trade industry stays at 6%, it will reach \$3 trillion by 2027, with about \$300 billion traced using blockchain technology.

The goal of the value chain remains the same — **to provide sustainable access to affordable food, feed, fiber and fuel.**

Recent food safety controversies all over the world drive transparency and food security up the political agenda. However, despite the fact that supply chain regulations tighten up, tracking food products has become a global problem. That's because, on average, every retailer delivering food to end consumer works with 27 intermediaries from 3 – 5 different countries, processes 240 copies of documents to every batch of product and 95% of that information has no value added. With current value chain complexity it takes 7 – 14 days to track down food products to their place of origin⁵³. This requires world governments, enterprises and independent businesses to coordinate efforts when tackling these challenges.

Corporate Social Responsibility

As more attention is devoted to sustainability, enterprises must consider that their ability to succeed long-term is dependent on the health and stability of the global environment and economy.



1 Natural ecosystem destruction

Examples:

Drought conditions, storms, and floods

Impact:

Reduced fishing and production causes food deficiency, price increases and therefore the emergence of new illegal markets.



2 Food supply systems change

Examples:

Rising temperatures and sea levels

Impact:

Lowered crop yield, strain on resources, increased market for counterfeit products.



3 Self-destructive production

Examples:

Deforestation and Overcultivation

Impact:

Reduced crop and fishing yields, irreversible environmental damage

To capture and capitalize on value in the 2020s, food value chain members need to determine if they are ready to take a leadership position as the industry continues to address the food safety issues. Apart from taming the technological advancements, food safety stakeholders will have to collaborate with their partners to build joint product and data transferring systems to reach transparency, traceability and trust.

Solution: blockchain innovation for food safety

**Data management and
traceability improved with
decentralized computing**

**Why blockchain will be a good fit
in 2020**

The last decade was an era of research and exploration for distributed ledger technology. The years leading up to 2020 have seen successful implementations of blockchain traceability programs, with major names such as IBM, and JD.com. In America, the FDA is on the verge of releasing a new food safety blueprint with standards regarding digital traceability in 2020 as part of the Food Safety Modernization Act.

Advantages of end-to-end traceability with blockchain

1 **Narrowed Trust Gap**

Build consumer confidence in brand and individual products through verified provenance and production data, share data with insurance providers and accreditors.

2 **Reduced Information Distortion**

Improve information visibility among supply chain partners leading to enhanced forecasting and collaborative planning.

3 **Consumer Engagement**

Create consumer touchpoints, share product & brand background, interact and receive feedback while earning repeat customers beyond the point of sale.

4 **Minimize Reputational Risk**

Prevent industry-wide scandals and costly recalls from impacting your brand by maintaining auditable and immutable data flows.

5 **Government Compliance**

Governments continue to adopt regulations covering food traceability, water conservation, pesticide usage, greenhouse gas emissions, and other areas of food production.

6 **Ethics and Sustainability**

Educate consumers on sustainable farming practices and company efforts to reduce supply chain emissions, promote biodiversity, and protect animal welfare.

According to the Grocery Manufacturers Association the average cost of a recall to a food and consumer product company is \$10 million⁵⁴, in addition to brand damage and lost sales. Blockchain technology allows for an instant track of any failure in a supply chain, which, in turn, makes recalls less frequent and decreases volumes of losses. With an average cost of blockchain implementation at \$200,000, technology will completely pay for itself upon the results of the first recall.

Distributed ledger technology is here to help

Blockchain, a type of distributed ledger technology, is a consensus of synchronized data spread across multiple computing devices. Data can be uploaded from permissioned sources such as logistical partners or IoT sensors. The decentralized and encrypted nature prevents any one partner from having total control over the data, bringing trust between stakeholders and encouraging automated connectivity.

Blockchain can be a major facilitator of collaboration, potentially adding government agencies, industrial organizations, regulators, insurance providers, accreditation services, NGOs, and other partners on top of your existing value chain. This automated flow of data eliminates paperwork, accelerates processing time, disintermediates various procedures, and maximizes the net value of your supply chain.

Looking at blockchain solutions up close

Individual products are serialised and associated with a digital twin on the blockchain. Touchpoints on the value chain collect data from stakeholders, equipment, and IoT sensors, both unique to the product or in batches.

Relevant data is automatically written to distributed storage, providing a secure and auditable record for consumers, insurance providers, regulators, accreditation service

providers, and other authorized supply chain partners.

QR codes on packaging are not just a means of sharing data from the tokenized product, they are a low-cost opportunity for a brand to earn trust, share engaging content, acquire feedback, gather analytics, and develop long-term brand-to-customer relationships.

Meats and seafood:

Possible data points recorded on the blockchain



Broodstocks & Seedstocks

Essential Data

Breeding Information, pedigree / breed composition, feeding practices, physical health data, animal registration data.



Farms, Hatcheries, & Broilerhouse

Essential Data

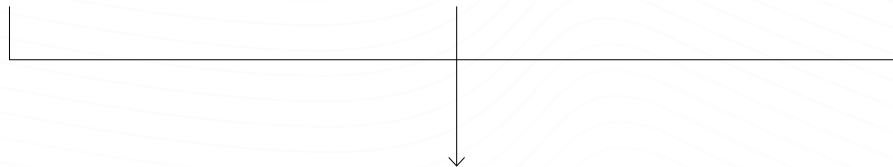
Geographical information, maturation practices, dietary compositions, health inspections, animal welfare certification.



Fishing & Processing

Essential Data

Transport conditions, stocking density, vessel & vehicle information, health & sanitation inspections.



Distributor

Essential Data

Transport conditions, cold chain storage data, health & safety inspections.



Import / Export

Essential Data

Licenses and certifications, logistics data, storage conditions.



Wholesale & Retailer

Essential Data

Point of sale data, transport conditions, cold chain storage data, licenses, health & safety inspections.



Consumer

Essential Data

Product evaluation, analytics, consumer engagement feedback.

Produce, fruit, and other food items:

Possible data points recorded on the blockchain



Farm

Essential Data

Genetic composition, geographical data, soil & weather data, fertilizer & pesticide use, ripeness and maturation controls, energy & water conservation, harvesting data, natural/organic certifications.



Processing & Packing

Essential Data

Process monitoring, health & safety certifications, additive use, reusable packaging.



Import / Export

Essential Data

Licenses and certifications, logistics data, storage conditions.



Wholesale & Retailer

Essential Data

Point of sale data, transport conditions, licenses, health & safety inspections.



Consumer

Essential Data

Product evaluation, analytics, consumer engagement feedback.

Main value drivers for blockchain

1 Increased transparency

In 2017 an outbreak of salmonella found in papaya caused a nose-dive in sales of the product⁵⁵, its retail sales plummeting from \$96 million in 2016 to \$88 million in 2017⁵⁶ affecting both food suppliers and farmers from unaffected areas. It took more than two weeks to track the source of contaminated papayas, whereas with integrated blockchain it can be done almost instantly (2.2 seconds according to IBM)⁵⁷.

2 Reduced fraud

In 2016 Interpol detected over 11,000 tons of either counterfeit or substandard food in 57 countries⁵⁸. Items can be tokenized and verified on the blockchain, resulting in product counterfeiting being reduced or eliminated in this relatively inexpensive process.

3 Enhanced financial management

Over 86 percent of global enterprises plan to invest more than \$1 million in blockchain in 2020⁵⁹, citing its potential in reducing redundancy and inefficiency that take place when several independent auditors check accounting for the supplier and the customer. Estimated value of technology is around 0.5% of total revenues (of total industry's value) which translates into about \$40 billion in benefit.

Technical requirements

A look at the hardware and software requirements for setting up a blockchain solution

For most blockchain platforms, enterprises have the choice to deploy on internal hardware or on a major cloud service provider. Private servers offer more control and security, but lose the flexibility and lower startup costs of a cloud solution. Below is an example of what is required to deploy on VeChain's public blockchain:



There is no pre-requisite for the type of cloud/hardware to use. VeChain's mission is to simplify and facilitate blockchain adoption through enterprise applications by providing a strong public blockchain infrastructure layer and a variety of simple-to-use tools and services for third parties developers and community members to adopt.

With that mindset, VeChain has developed VeChain ToolChain™ which provides a ready-to-use SaaS platform as well as RESTful APIs for a more customizable approach. Third party developers can easily interact and create blockchain solutions without in-depth blockchain or smart contract development capability. Developers or enterprise users can simply use the off-the-shelf SaaS platform or integrate APIs directly into their existing hardware and software infrastructure.

Additionally, developers can also choose to build directly on VeChainThor blockchain using the tools available on GitHub. In case if one wishes to deploy a standard node, this is the minimum recommended specs for the hardware:

- CPU: 2.0 GHz Quad-Core
- Memory: 12 GB
- HDD: 500 GB

Who are the existing players in the market and what's the comparison?

A look at the major vendors providing blockchain services

The industry is filled with established enterprises and new startups offering BaaS platforms. Choosing the right one is a difficult proposition, and requires careful evaluation of the vendor's strengths to match enterprise needs. Blockchain platforms can be categorized into the following three segments:

1 Private blockchains and consortium chains:

These permissioned networks have pre-assigned nodes validating data, with write and read access limited to internal parties. External read access can be assigned on a per-need basis.

Advantages:

Secure, Stable, Scalable

Disadvantages:

Low-transparency, high upfront costs

Companies:

IBM Blockchain



2 Public blockchains:

Permissionless and open, these networks are secured by anonymous node validators bringing a higher level of trust to the network.

Advantages:

Transparent, Open, Low-cost

Disadvantages:

Unstable development environment, lack of support, fluctuating transaction fees

Vendors:



ethereum



neo

3 Hybrid Chains:

Permissioned but public, these chains allow for more stability while maintaining the trusted environment of a public chain.

Advantages:

Stable, low-cost, transparent

Disadvantages:

Less decentralized than public blockchains, less control than private blockchains

Vendors:

vechain

Kadena

Case studies

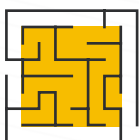
Blockchain — a game changer
in the food industry



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My Story™ by DNV GL Business Assurance



The problem

Companies today are under pressure to manage performance and value chains in a sustainable and transparent way. With consumer trust shifting from brands to products, DNV GL Business Assurance recognized the importance of providing traceable product data on food and beverage items such as seafood and wine.



The solution

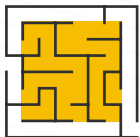
The My Story™ solution provides instant access to verified data stored on a blockchain ledger. DNV GL ensures this data is authentic, connecting consumers with trustable information about production processes, brand history, and the product's journey through the supply chain. The solution is running on VeChain's public blockchain.



Key features

The My Story™ ecosystem includes user management and connectivity options for IoT devices and it is a scalable and affordable enterprise solution. The consumer, through a QR-code on the product, can dive into aspects of interest on their smart device.

Bytable



The problem

Enable tracking of eggs from farm to consumer to ensure the freshness of every product.



The solution

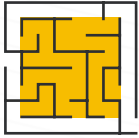
Building a blockchain layer using Hyperledger Sawtooth food traceability software. QR-code stickers were placed on egg cartons which could be scanned by customers. Data was captured at each stage of the product life-cycle and made searchable by date and time information on the end of the egg carton. Feedback forms gave retailers insights about customers.



Achievement-to-date

The goal was to receive a 5 – 10% scan rate with average engagement of 1 minute. In reality, the scan rate was 22% (of 11,000 stickered cartons) with average time spent on a web app of 2 minutes and 48 sec⁶⁰.

IBM Food Trust



The problem

Food recalls are an immense safety problem and a threat to profitability. Last year, Food Safety Magazine counted 456 food safety recalls globally due to contamination, with each recall estimated to cost an average of \$10 million⁶¹. In addition to the societal and business impact, huge stocks of food are wasted and consumer trust is diminished.



The solution

IBM Food Trust created a secure, shared, and permissioned record of transactions. This enables unprecedented visibility during each step of the food supply chain.



Key features

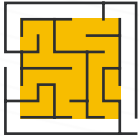
Blockchain technology stores digitized records in a decentralized and immutable manner, promoting trust and transparency which in turn helps to better the food system and ensure safer food.



Achievement-to-date

Reduced time of food traceability to only 2.2 seconds, shipping time for items was reduced by 40%, while query time about the location of a cargo item was reduced from 10 steps to 1⁶².

Carrefour Food Trust



The problem

Carrefour branded products lack the brand image of established major food brands.



The solution

Providing each food product with QR-codes which once scanned could provide any customer with product information stored in blockchain ledgers. Carrefour, which operates more than 12,000 stores in over 33 countries, was able to track and trace its prepared food products (20,000 chickens, 10,000 eggs, tomatoes and other food)⁶³. This also gives the Carrefour branded products a valuable boost in differentiation and consumer appeal.



Key features

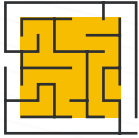
By creating a decentralized ledger that records transactions in a global food network, blockchain is being used to untangle the dense web of growers, suppliers, manufacturers, retailers, regulators, consumers, and restaurants. The secure data-sharing platform lets participants share information about food origin, processing, and shipping information in a permissioned way, ensuring the data and insights remain the property of the respective companies. The governance model is enforced by the Food Trust's Advisory Council, comprised of a range of industry innovators and leaders.



Positive outcomes

10% increase in time spent by customers in supermarkets while scanning QR-codes and reading merchandise information. Increase in pomelo and "blockchain" chicken sales by \$3 million building "halo" effect: "If I can trust Carrefour with this chicken, I can also trust them for their apples or cheese". Steep increase in consumer's trust in the food products from 33% to 51%⁶⁴.

JD.com



The problem

Lack of traceability of goods, low efficiency of traditional inventory management, counterfeit and fraud in the food supply chain.



The solution

The platform, known as the JD blockchain Open Platform, is designed so that enterprise customers can easily create and adjust smart contracts running on public and private clouds. Using this capability, JD.com's platform would allow companies to streamline data management and operations such as tracking the movement of goods, charity donations, authenticity certification, property assignment, transaction settlements, digital copyrights and more.



Key features

The JD blockchain Open Platform operates as a service accessible to enterprise customers and is designed with the concept of "one-click deployment" in mind. Applications, tools and software for the platform are developed in-house by independent software vendors vetted by JD.com, which can then be implemented by enterprise users without the need for expert knowledge in blockchain or development.



Achievement-to-date

The company has implemented blockchain tracing for more than 400 brands and 11,000 stock keeping units on the JD.com e-commerce site⁶⁵. There have been 1.3 billion pieces of uploaded data⁶⁶.

Attaining new possibilities with blockchain

With the support of emerging technologies, it is possible for all stakeholders to make a difference. Joint efforts from enterprises, governments, and blockchain vendors can lead to a higher standard of food production with regard to safety, transparency, and environmental impact.

To-dos for Enterprises

- Reassess existing supply chain processes for areas in need of transparency and quality control.
- Cooperate with blockchain vendors to implement traceability solutions.

To-dos for Governments

- Continue to create and enforce regulations expediting the adoption of higher food safety standards.
- Promote a culture of innovation by supporting startups and enterprises working on food safety initiatives.

To-dos for blockchain Vendors

- Develop enterprise-grade solutions that are secure, intuitive, and demonstrate clear value to stakeholders.
- Continuously work towards increased scalability and efficiency making interoperable solutions more practical.

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