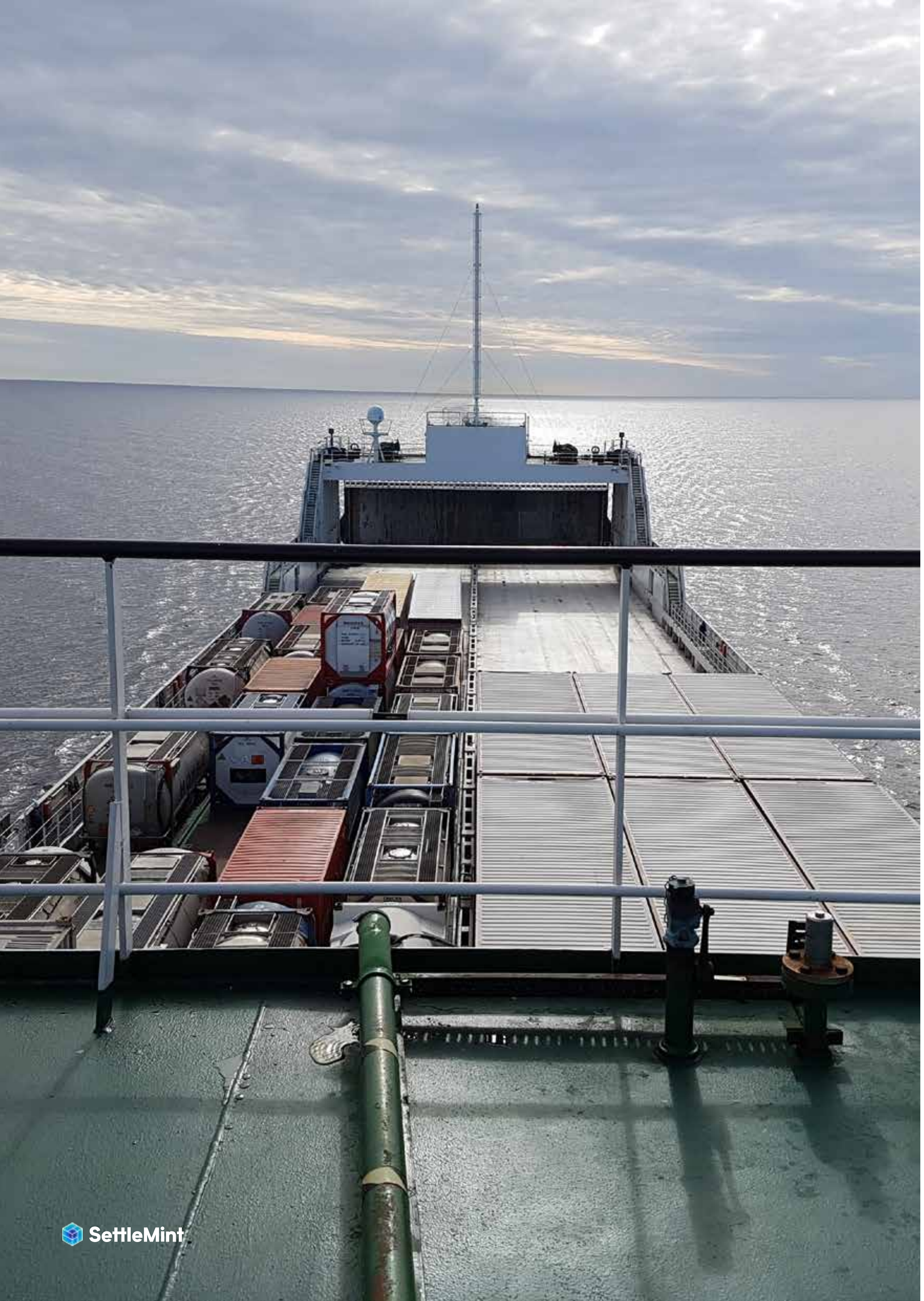
HOW BLOCKCHAIN-SUPPORTED CONSUMER GOODS SUPPLY CHAIN WORKS, WHAT THE CHALLENGES ARE, AND HOW ORGANISATIONS CAN MEET THEM.

CONSUMER GOODS SUPPLY CHAIN: BETTER ON CHAIN?

SettleMint

INDEX

SettleMint NV Arnould Nobelstraat 38 — 3000 Leuven (Belgium) — hello@settlemint.com



Failure to adequately manage the food supply chain results in huge wastage, lost lives, and missed opportunities. Food Supply Chain Management (FSCM) has emerged as a modern discipline with much promise in this regard. At the corporate level, improved FSCM represents a competitive advantage in terms of cost savings, improved access to financing, and ability to provide value-added services. At the societal level, enhanced FSCM supports sustainability by preventing food wastage, ensuring compliance with environmental standards, and helping quality producers earn fair compensation for their efforts.

Blockchain-supported FSCM has repeatedly been put forth as a panacea for the problems within status quo FSCM solutions; the argument being that a blockchain supported, decentralized FSCM solution is the best way to finally achieve the needed level of coordination amongst the many disparate parties in food supply chains towards the goal of achieving all the above mentioned improvements.

This report, in seeking to determine the best way to improve FSCM, outlines the challenges in the status quo, explores the potential of blockchain supported FSCM solutions, and analyses some of the current real-world deployments in terms of their achievements, potentials, and shortcomings.

PART I: CHALLENGES IN THE STATUS QUO OF FSCM

TRACEABILITY

Tracing the origin of a food product and the ingredients it contains sits at the heart of FSCM. It is critical for upholding food safety, enhancing consumer confidence, and increasing logistical efficiencies in the supply chain. Unfortunately, in the current state of FSCM, tracing foods is time consuming, inexact, and in some cases effectively impossible.

Why is tracing foods so hard?

As with most complex systems, the problem stems largely from the difficulty of coordinating amongst the wide and disparate participants in the chain, who in the case of food supply range from producers to inspectors and regulators, customs officials, transport providers, processors, wholesalers, distributors, retailers, and finally consumers. Coordination amongst these participants is hampered by the division of labor in the value-added chain of agribusiness.

As pointed out in an analysis of the criteria for the efficient and effective application of Electronic Data Interchange (EDI) technologies in food supply chains, this leads to the ***"development of organizational intersections which act as fractures in the information flow"***.[1]

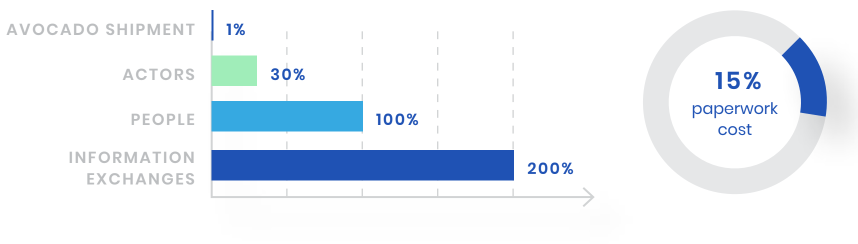
Relative to other supply chains, food supply is a particularly challenging beast due to the acute need to manage food quality and freshness along the way — and for most foods, time is very much of the essence.

Adding to the complexity, food supply chains lengthen and intertwine in the global era, where grain harvested in Europe is routinely used for craft beer produced in Korea. Complexity is further amplified by the number of ingredients in a given food product. Where more than a quarter of all processed foods now contain ingredients from at least five countries,[2] unravelling the supply chain to identify, for example, the source of a tainted product, is an increasingly daunting task.

The difficulty of tracing products in the food supply chain is largely a consequence of the disparate record-keeping methods in use across industry participants. A Harvard Business Review overview of supply chain management, for instance, found that, thanks to ***"organizational changes, merges, and acquisitions over time,"*** large organizations may have more than 100 legacy Enterprise Resource Planning (ERP) systems. The authors noted that one large company had *"17 ledgers in separate ERP systems associated with a single activity—trucking—and its suppliers and distributors had their own ledgers and ERP systems."*[3]

This type of Balkanization of supply chain tracking prevents participants from sharing information beyond a single step in the supply chain, making it next to impossible to garner a holistic view of the chain.

Additionally, the volume of documentation that is required to accompany food shipments presents an enormous challenge for FSCM, particularly where supply chains cross borders. Consider the example presented in a 2017 report from IBM that was compiled in collaboration with shipping giant Maersk who was looking to streamline its container shipping process using IBM's solution. The report found that a single shipment of avocados from Mombasa, Kenya to Rotterdam, Netherlands involved 200 information exchanges between 100 people across 30 separate actors.[4] The shipment was completed in 34 days, but nearly half of that time was eaten up by the need for port authorities to await shipping information and government document approval.[5] The total cost of shipping a single container was calculated at approximately $2000 but 15% of that cost was derived from just the paperwork associated with the shipment.[6]



source : www.unescap.org/sites/default/files/3_IBM%20Blockchain.pdf

Whether for documentation required by authorities or documentation needed for efficient trade between nodes in the supply chain, there is very little standardization of the data that is recorded, how it is recorded, and how it is exchanged. Level of sophistication ranges from handwritten records to bar codes and RFID tags. Even within a single link in the chain, multiple electronic systems in use may not have the ability to natively communicate. For example, according to a report compiled *the Institute of Food Technologists* and submitted to the *US Food and Drug Administration*, food companies' batching systems often cannot natively communicate with warehouse management systems, which cannot natively communicate with accounting systems.[7]

Further compounding the problem, information identifying a product may be provided on associated paperwork but not on the product itself. Loose produce is often sold without a label, making it almost impossible to be individually tracked at the point of sale. In the case of individually packaged foods, which are typically easier to track, some packages are too small to contain labels. Finally, even if the needed information were contained on the end-product, most retail outlets cannot yet capture lot-specific information during transactions with customers.[8]

When food products contain multiple ingredients, complexity is increased by an order of magnitude. Where a single tainted ingredient is contained in thousands of products, it can take months to correctly identify the affected items. For instance, a 2009 salmonella outbreak - eventually linked to peanut paste from the Peanut Corporation of America - lasted for months because suppliers were unaware that their foods contained the tainted ingredient. The US Centers for Disease Control, in its report on the incident, could only speculate as to the true scale of the contamination, writing:

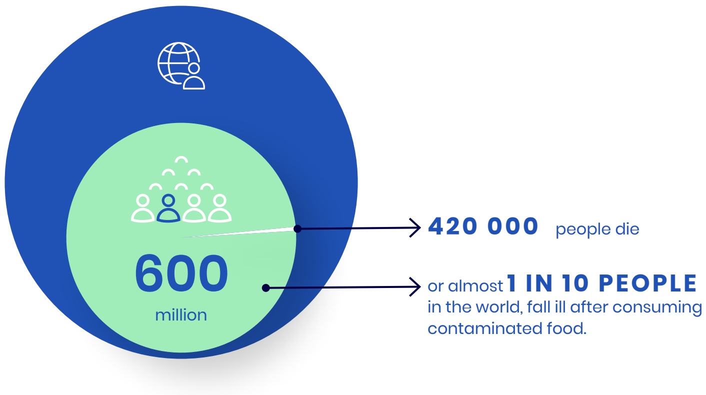
> *"other peanut containing products produced by a variety of companies may have been made with the ingredients recalled by Peanut Corporation of America."*[9]
>
> *— The US Centers for Disease Control*

Further hampering traceability in FSCM is the deliberate actions of bad actors. The ease with which it is possible to commit fraud in the food supply chain is amplified by the traditional database processes employed in status quo FSCM, where bad actors can alter database entries without others in the supply chain knowing it.

CONSEQUENCES OF POOR FSCM

The consequences of failure in managing food supply are severe: *World Health Organization data* show almost 1 in 10 people get sick due to foodborne disease each year, and close to half a million die.[10] Despite common conceptions, this is far from being a "developing world" problem. For instance, in the European region, which "has the lowest estimated burden of foodborne diseases globally," 23 million people still fall ill from unsafe food every year, and 5000 die.[11] Even for basic single-ingredient commodities like fruits and vegetables, failure to adequately manage the supply chain results in huge wastage. As much as a third of all food produced globally, in fact, ends up abandoned — two thirds of it before reaching the shelves.[12]

THE ESTIMATED BURDEN OF FOODBORNE DISEASES GLOBALLY



The inability to adequately trace foods in the status quo of FSCM has long-lasting and serious consequences. When it comes to tracking foods in, for instance, the event of an outbreak, the now widely-accepted **"one up, one down" approach** – where participants are required to know only the immediate supplier (one link up the chain) and the immediate customer (one link down the chain) for a product—makes it **extremely difficult to get a clear picture of the entire chain**. Investigators must inquire individually at each node in the supply chain as they painstakingly work their way to the source of contamination.[13] When, for example, there was an outbreak of E. coli in the US in 2006, it took health officials two weeks to identify the source of the contamination, which turned out to be a single day's production from a single supplier[14].

Unable to pinpoint the source in a timely manner, officials were forced to call for the blanket destruction of all fresh spinach in a number of states in the US, with a ban on spinach sales remaining in place for more than two weeks.[15] The immediate impact of the outbreak on the industry was the economic loss of an entire crop of spinach as the product was pulled off shelves, ripped out of residential refrigerators, and destroyed nationwide. However, the long-tail impact of the shattering of consumer confidence in spinach was felt by spinach producers and distributors for years. More than a year after the incident, for instance, bagged spinach sales were still down 10% from pre-crisis levels, as shown in data from the US Department of Agriculture.[16] In the above described tainted peanut paste incident, due to the inability of investigators to granularly track ingredients in the supply chain, entire shipments had to be destroyed as a precaution. In the end, more than 3,200 different food products were recalled. Estimates of the financial damage to the peanut industry topped $1 billion.[17]

Demonstrating the cross-border nature of supply-chains, in late 2019, Canada experienced its fourth E. coli outbreak in two years linked to romaine lettuce. This time the source was determined to be spinach farms located in the Central Coast growing regions of northern and central California but, unable to pinpoint the exact farm, blanket destruction of romaine lettuce from the region was advised.[18]

BAGGED SPINACH EXPENDITURES PLUNGED IN RESPONSE TO FDA ANNOUNCEMENT, SEPTEMBER 2006 - DECEMBER 2007

Expenditures ($ millions)

Note: Week zero is the week prior to and week 1 is the weekend of the announcement. Since the data are weekly and the 5 days when there was no spinach on the market were spread over weeks 1 and 2, the figure does not show actual expenditures falling to zero.

Source: USDA, Economic Research Service model results

Deadly outbreaks from contaminated foods are truly a global problem. For example, the 2011 E. coli outbreak in Germany resulted in nearly 4000 illnesses and 53 deaths, making it a "top 3" worst food contamination disaster in modern history. It took over a month for investigators to determine the exact source of the outbreak, which was a single organic sprout farm in Lower Saxony, Germany.[19] The economic consequences of the inability to track the source of the contamination were stark. Russia placed a blanket ban on all vegetables from Europe and, amid rumors that the source of the outbreak was cucumbers from Spain, the consumption and export of vegetables from Spain dropped precipitously. Eventually the European Union compensated farmers in a number of vegetable-exporting countries to the tune of 220 million Euros for loss of income.[20]

Recalls: a growing problem

Making matter worse, **food product recalls** are on the rise globally. In the US, recalls increased by 10% between 2013 and 2018, with a record of more than 800 in 2016,[21] while in the EU the number of recalls increased from 519 in 2013 to a record high of 818 in 2017.[22] Food companies suffer the most direct and quantifiable economic losses from food product recalls, which are said to cost an average of $10 million for a single food company[23] with 5% of food companies reporting direct and indirect losses of $100 million for a single recall.[24] Significant supply chain disruptions reduce the share price of affected companies by seven percent on average according to a 2013 report prepared for the World Economic forum.[25]

Food fraud is estimated to cost the global food industry $40 billion per year.[26] Notable examples here include the 2011 pork mislabeling debacle in China and the 2013 horsemeat scandal in Europe. The latter, in which meat containing horse DNA was sold as beef, affected 4.5 million processed products representing at least 1,000 tons of food.[27] In both cases public trust in food supply was eroded, foods were wasted, and business' bottom lines were negatively affected.

Due to the prevalence of high-profile incidents like the ones described above, consumers are increasingly placing importance on food safety. A 2018 survey from UK industry magazine *Food Manufacture*, for instance, found that more than two-thirds (68.3%) of participants worry about food fraud problems.[28] **Consumers are demanding transparency into the supply chain for the foods they purchase**. Further, increasingly aware of sustainability issues, consumers are demanding **sustainably sourced and transported foods**. They want to know the source of the ingredients and they want more information about the journey of ingredients from farm to fork. Businesses which cannot provide sufficient transparency into the supply chain of their products are now at a competitive disadvantage. The European Commission, for instance, pointed out in a 2016 report that the EU food industry – which is the biggest manufacturing sector in Europe in terms of jobs and value added - is facing a decrease in competitiveness caused by a lack of transparency in food supply chains.[29]

SettleMint

PART II: SOLUTIONS

Achieving coordination amongst the participants in food supply chains is difficult because wildly diverse people and enterprises, each with differing goals, are involved in the production, processing and distribution of food stuffs. These diverse actors, some of whom have very limited economic resources, must somehow be motivated to ensure the complete and correct gathering and sharing of information needed to guarantee traceability.

The ideal solution would offer a real-time shared view of the truth for each permissioned participant while maintaining for each participant, ownership and control over his own information. To achieve that, some of the key features needed for a viable FSCM solution include:

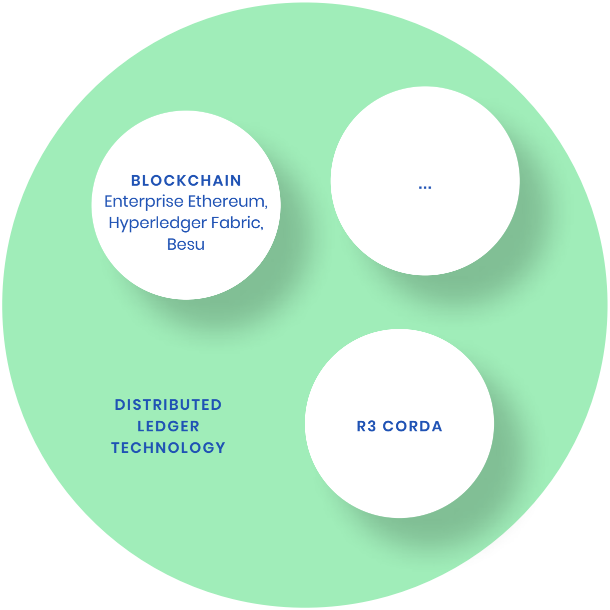
- **Open standards** that can be seen and verified by all
- Existing on **a vendor-neutral platform**
- **Security** of sensitive information
- Granular permissioned-only **read/write access**
- **Longevity** of important information
- The ability to see information in (effectively) **real-time**
- **Low costs** to join the network.

THE BLOCKCHAIN SOLUTION:
How it works

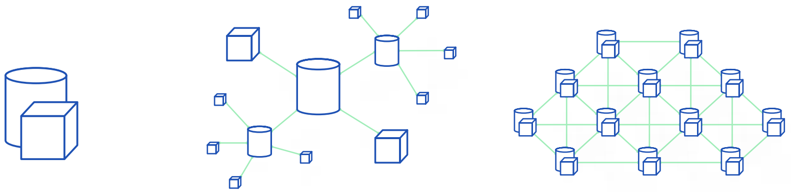
Blockchain-supported decentralized FSCM solutions can in theory satisfy all of the above-listed essential features needed to make a truly transformative impact on FSCM. In practice, they do this by using a different type of database – one that is immutable and distributed by design.

In essence, a blockchain falls under the umbrella of Distributed Ledger Technologies (DLT). It is important to separate terms such as “distributed ledger” and “decentralisation.”

By definition, **a distributed ledger** gives the control of the evolution of the data itself to its participants, also known as nodes. Blockchains in principle share the data across all the nodes, irrespective of the topology, be it public or private. This data redundancy requires that all nodes possess all the data on a blockchain at any given time. Then there are distributed ledger technologies that take a different approach. *R3 Corda*, for instance, is a distributed ledger, yet not a blockchain. Thus both blockchain and Corda can be considered a subset of DLT.



It is also important to observe that the terms “decentralization” and “distributed” are two very different things. We choose to align with the below illustration for a clear understanding of **distributed networks**:



CENTRALIZED
one node does everything

DISTRIBUTED
nodes distribute work to sub-nodes

DECENTRALIZED
nodes are only connected to peers

image source: https://www.quora.com/Whats-the-difference-between-distributed-and-decentralized-in-Bitcoin-land

One can say that distributed networks are a form of decentralization. Unfortunately, there is a lack of taxonomy on the matter. As mentioned by Ethereum co-founder *Vitalik Buterin*,[30] however, there is more to decentralization than the *simple* illustration mentioned above. To quote:

> *"Blockchains are politically decentralized (no one controls them) and architecturally decentralized (no infrastructural central point of failure) but they are logically centralized (there is one commonly agreed state and the system behaves like a single computer)."*
>
> *— Vitalik Buterin, co-founder Ethereum*

Consensus is another core property of blockchain-based database system. At the technical level, consensus is achieved by establishing an agreed upon and open protocol for updating the database, whereby all participants are free to verify the validity of information contained in it. Further, since the architecture of the protocol can be such that neither the users nor the operators of the system have the capacity to alter it, all participants are freed of the need to assess the trustworthiness of intermediaries or any other participants in the network.

Here lies part of **the clear added value of Blockchain: Zero fault tolerance**. Another advantage is its **immutability**. Since a Blockchain is *politically decentralized* (by consensus mechanisms), it is impossible to modify transactions without affecting the entire chain, thereby compromising the entire ledger. Such a state would not be accepted by the other participants on the network.

INTEGRATING STATUS QUO IT SOLUTIONS WITH BLOCKCHAIN

Electronic Data Interchange (EDI) was first introduced in the commercial sector in the 1980s as a way to facilitate the paperless exchange of supply chain documents like purchase orders, shipment authorizations, shipment acknowledgements, advanced shipment notices, and invoices. Maturing in the late 1990s, several EDI protocols were developed and implemented separately and with varying degrees of success in the food supply chain. It can be said that EDI protocols as a whole achieved meaningful adoption by the early 2000s, with as many as 70% of large firms in the US food supply chain for instance, using one or more of them for at least one part of their documentation processes by that time.[31]

In a nutshell, EDI is a standard or protocol for businesses to effectively communicate with one another. Well known messages such as *Purchase Order* or *Dispatch Advice* are contemporary EDI Messages. Several standards such as EDIFACT and X12 were derived from EDI.

Whilst EDI may streamline the flow of documents between certain nodes in the food supply chain, it doesn't enable the needed holistic view of the supply chain. Next, even as a tool for document exchange, **EDI has limited utility due to the lack of standards within and between EDI protocols**.

There are at least four major EDI standards, with updates constantly being made to each protocol – and since businesses cannot communicate across EDI standards or versions, **the usefulness of the system is severely limited from the start**, particularly where a supply chain traverses multiple regions. Finally, the high cost of implementation of EDI protocols limits their adoption to large enterprises in food supply chains, severely hampering the deployment of holistic FSCM.[32]

These factors combine to make EDI an insufficient tool for markedly improving FSCM. As one study of EDI adoption found:

> *"while most firms used EDI for the frequent and routine transactions, invoices and purchasing orders, they were not using EDI as often for the transactions that are more coordinating, such as transferring current schedules, production, and sales activities."*[33]

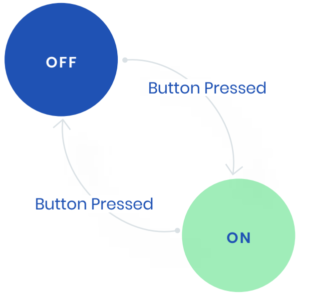
In other words, EDI hasn't been able to solve the more complex coordination problems in food supply chains. Firms are primarily using EDI as a tool for making minor efficiencies improvements rather than as a tool for developing holistic (transformative) FSCM.[34]

Although the above assessment of EDI depicts a somewhat unfavorable picture, EDI has in fact provided a good starting point for an eventual holistic solution. One can argue that whilst EDI has too many standards, blockchain is still far from having its own general standards, let alone supply-chain related standards.

The issue with EDI is that it is not always easy to link all messages together to form one common narrative about a specific order, especially when dealing with a complex supply chain that integrates a hierarchy of third-party logistics. Here, we believe, lies blockchain's contribution.

Having features such as immutability and smart contracts out of the box, blockchain can anchor EDI messages to one common flow, providing one, immutable and traceable (thereby auditable picture) of an order. And since every participant - be it a third - party logistics company, a supplier, or a carrier - owns a copy of the *blockchain*, product tracing is easy and helps deal with issues such as product recall or billing in a far superior manner.

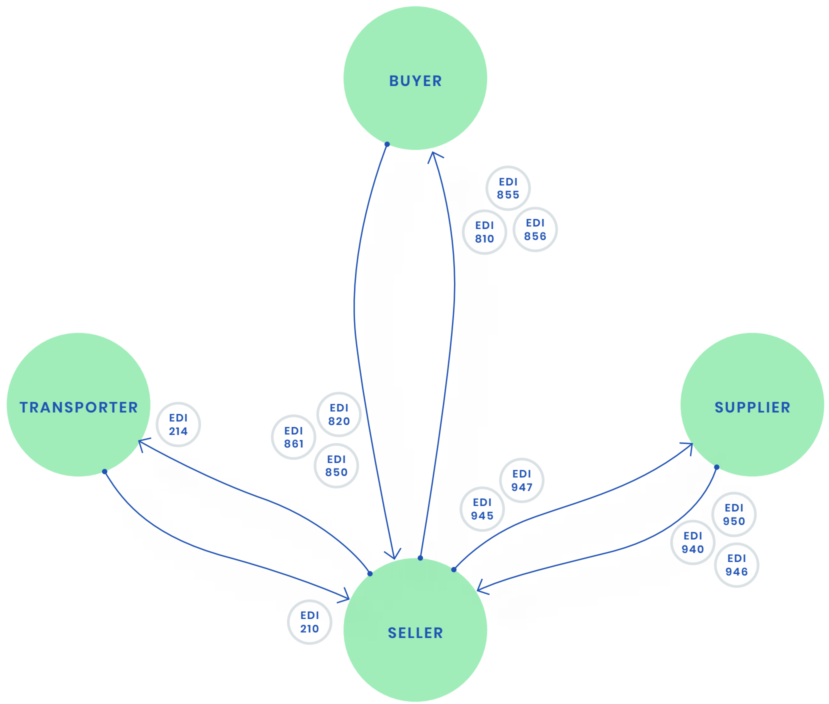
A blockchain can operate seamlessly with EDI through the application of 'state machines.' By definition, a state machine is a model that can enclose a task into a number of sub-tasks. To proceed from one state to the next, an action, or transition, is necessary.



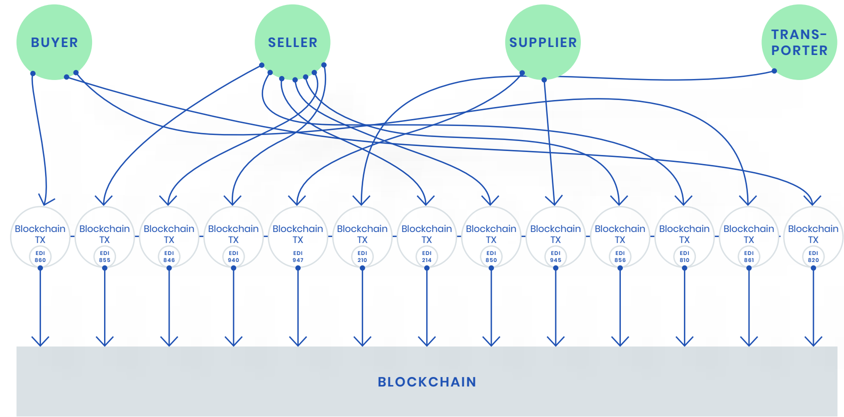
The above image, which shows a simple light switch, illustrates a state machine model. The states are two (OFF and ON) and there is one action that can transition between the two states (the button press).

With use-cases in mind, one can see why this is advantageous. When you use state-machines, you are dividing a big process into smaller and more manageable tasks towards the goal of reducing errors, **improving efficiency, and enabling automation**.

When you outline a more complex process using the state machine model, it is easier to map the process lifecycle out and you will be less likely to encounter a situation where you don't know what's going on in your process. Afterall, there is a finite number of steps – each known as a state - and your process must be somewhere in it.



In the case of a simple shipment order, various EDI messages exist as we can observe in the above example. In linking EDI messages to blockchain transactions, we can link these messages and identify states that move an order from one phase to the next. By default, **a state is always the result of a current state and an action**. So, a purchase order and an action (such as "sent to seller") would then result in an "order acknowledged" state.



The above diagram shows all EDI Messages, re-organized into transactions in a linear manner. **Combining EDI Messages with state machines on blockchain ensures that an order can always be traced to a message at any given point.**

KEY BENEFITS OF A BLOCKCHAIN-ENABLED SOLUTION

A significant benefit of a blockchain-enabled system for tracking supply chain data is that it provides each permissioned participant with the ability to check any aspect of the supply chain flow in real time. This has wide implications for all stakeholders.

For businesses, it improves the ability to coordinate, resulting in logistical efficiency gains that range from reduced food wastage to just-in-time delivery capability, lowered accounting and auditing costs, automated payments, and improved financing options. Businesses can also differentiate themselves by offering more transparency into their products for consumers.

For regulators and other authorities, a blockchain-enabled system provides **the ability to track the entire supply chain from start to finish** with a few clicks instead of having to request data from each entity manually as in the status quo. For consumers, it provides the transparency into the supply chain needed to make more informed purchase decisions. Finally, all participants in the supply chain benefit from the reduced level of fraud that is made possible by the more open data enabled by a blockchain-powered supply chain.

ADVANCED BLOCKCHAIN SOLUTION:
A vision of the future

All of the benefits of a blockchain approach combine to create a FSCM system that could potentially have **revolutionary impacts**. Given enough data, distributors and consumers alike could, for instance, know that producers and manufacturers along the chain adhere to sustainability practices like **paying workers fairly, not polluting, or using renewable energy sources**.

Another feature of a fully blockchain-enabled supply chain management system is the ability to **automate procedures using smart contracts** (contracts that execute automatically when predefined conditions have been met). For instance, payments from buyers to suppliers could be triggered automatically when defined conditions have been input into the system by verified actors. Used in combination with Internet of Things (IoT) enabled sensors, and with all stakeholders on board, major processes across supply chains could in theory be completely automated with full transparency for all permissioned participants. How would this look?

IoT enabled sensors in farmer's fields, chicken pens, etc., could transmit information like soil, water, air, and temperature conditions during the production process. Harvested foods would be labelled with RFID tags either individually (as in the case of livestock) or in lots (as in the case of grains) that mark the foods as having been produced under the conditions as recorded by the IoT devices. All information would be stored on the blockchain with access granted to permissioned participants.

Moving along the supply chain from producer to processor, transactions could be automated by smart contracts. As products change hands, data is verified by participants, and payments are released. Producers of high-quality produce who have been verified as adhering to sustainability practices could be rewarded with higher prices, their produce granularly tracked and separated so that it can be differentiated, all the way to consumers. Transaction data would be stored on the blockchain along with sensor data captured during transport and processing. As food products move through the supply chain, data could be added to each lot by scanning its RFID tag. Managers, seeing real-time data like temperature, humidity and storage time, could make informed decisions as to which specific products should be given priority for removal in order to avoid losses.

Retailers, empowered with complete information about the products on their journey along the supply chain, could make more appropriate purchasing decisions. Consumers, as they scan QR codes on the items in the shop, are also presented with complete "farm to fork" information, boosting their confidence in the products' quality.

Certification and auditing authorities, who may randomly check at various on-premise points in the supply chain whether reporting has been done accurately, would also have full visibility into the supply chain. This would simplify their audits and improve the credibility of their certifications, not to mention empowering them to trace the source of outbreaks in minutes rather than weeks.

PART III:
REAL WORLD DEPLOYMENT OF BLOCKCHAIN-SUPPORTED FSCM

PROMINENT EARLY PILOTS AND THEIR RESULTS

A variety of pilot studies have demonstrated the benefits of blockchain-supported FSCM solutions, proving the efficacy of the technology. Some of these pilot studies have evolved to in-production FSCM systems that are now growing in both size and adoption. Here we describe in some detail three projects that are representative in this regard.

Walmart Carrefour Albert Heijn ABInBev

Walmart

In 2016, Walmart worked with IBM to use a blockchain-based system to track mangos in the supply chain. The pilot, which was one of first in the FSCM sector, was instrumental in the formation of what would later become the IBM Food Trust. Under Walmart's status quo traceability system - where each stakeholder was required to individually contact the next in the chain - it had taken just under a week on average to establish a mango's provenance. Under the blockchain-supported system – where, as the mangos pass each stakeholders' station along the supply chain, participants recorded data to a shared distributed ledger - trace time was reduced to 2.2 seconds. Walmart simultaneously conducted a blockchain-pilot on its pork supply chain in China. In that pilot, veterinary certificates were stored on chain rather than passed on manually by truck drivers. This system provided instant access to any trusted user on the network and "increased confidence in those records."[36]

The impacts of Walmat's early pilots on its FSCM map closely to the benefits described in the above [Key benefits of a blockchain-enabled solution] section. They included increased transparency, enhanced food flow, less fraud, and reduced waste. The latter benefit aligns nicely with Walmart's "commitment to achieve zero waste to landfill in key markets by 2025, and to sell more sustainably produced products while maintaining the low prices customers expect."[37] The project lead from Walmart concluded in a 2018 report, "Because blockchain protocols are based on decentralization and consensus, it could help food system stakeholders restore and scale consumer confidence in food, and in the institutions that are part of the nation's food supply."[38]

Walmart's initial pilots quickly moved into production environments and expanded into a wider variety of products. By May 2018, the retail giant had tracked "nearly two dozen SKUs involving 2.6 million food packages across 166,000 traceability events on the blockchain."[39] In the wake of a growing number of tainted lettuce incidents, Walmart introduced blockchain-supported FSCM for its leafy greens, demanding that all suppliers of leafy greens join the system by a deadline of September 2019.[40] In 2020, Walmart expanded to integrate green bell pepper suppliers.

source: www.digital.hbs.edu/platform-rctom/submission/walmart-from-supply-chain-to-blockchain

Carrefour

In March 2018, Carrefour started by launching blockchain-supported FSCM for its Auvergne Filière Qualité Carrefour chicken. The system, which also relied on IBM's blockchain solution, enabled consumers at select Carrefour locations to use their phone to scan a QR barcode to see detailed information about the source and journey of the chicken from farm to shelf. In mid-2019, Carrefour expanded on the chicken-pilot, launching blockchain-based tracking for 20 items including eggs, raw milk, oranges, pork, some fruits, and cheese. Customers could scan a QR barcode on an item to find out the date of harvest, location of cultivation, the owner of the plot, when it was packed, how long it took to transport to Europe and tips on how to prepare it. According to the project manager, the increased transparency resulted in improve sales. Emmanuel Delerm was quoted in a June 2019 Reuters article, "The pomelo sold faster than the year before due to blockchain [and] we had a positive impact on the chicken versus the non-blockchain chicken."[41]

According to a June 2019 report from Forbes, the France-based global retailer would add 100 more products in 2019, "with a focus on areas where consumers want reassurance, like baby and organic products."[42]

In February 2020, it was announced that Carrefour were taking delivery of 300,000 bottles of organic wine tracked using its blockchain-supported FSCM system. A unique QR Code on each bottle's label leads customers to a web page with the organic certification, a map showing the location of the winery, the date and location of bottling, and tasting notes by the Johanès Boubée negociant company.[43]

Interestingly, Carrefour's blockchain-supported food provenance initiatives have so far been most popular at the retailers stores in China, where consumers are already accustomed to scanning QR codes and where consumers have a relatively low level of confidence in supply-chain integrity thanks to a number of high-profile incidents in the country.

According to Carrefour's corporate website, the objective is to apply the system to all food products in its Auvergne Filière Qualité Carrefour line by 2022.[44]

source: www.vitisphere.com/news-91229-How-Carrefour-demonstrates-the-traceability-of-its-organic-wine-using-blockchain-technology.htm

Albert Heijn

Another early entrant in the blockchain-enabled FSCM sector was Albert Heijn, the biggest supermarket chain in the Netherlands. As early as September 2018 the retail giant was using blockchain to track the supply chain of its branded orange juice, making the information transparently available to consumers. Consumers could scan a QR code on the orange juice containers instore to reveal information on the product's journey, which starts at Brazilian plantations owned by LDC Juice that are certified to be "deforestation-free." Information such as when the oranges were picked, their level of sweetness, processing period, transport time, color, and taste tests was all added to the blockchain in its 9-step journey from farms to store shelves.[45]

Albert Heijn Commercial Director Marit van Egmond said in a September 2018 statement, "The importance of transparency in the supply chain continues to increase. We know all the steps in the supply chain of our products, to ensure they are produced with respect for people, animals and the environment. And we want to show these steps to our clients as well, be open and transparent."[46]

Having successfully rolled out blockchain-supported FSCM for its orange juice, Albert Heijn moved on to tracking eggs. As of spring 2020, the retailer provides full transparency into its egg supply chain, showing consumers which farm the egg came from, when it was laid, and when it arrived at the store.

Lessons learned & challenges

While the early prominent blockchain-enabled supply chain solutions have seen real adoption and have demonstrated tangible benefits, these projects have also provided lessons that are valuable for organizations looking to benefit from the technology going forward.

Challenge 1: Engage all stakeholders in a supply chain

For the fully holistic view of the supply chain that's needed to unleash the highest level of benefits for all stakeholders, including achieving sustainability goals, accurate **data from first-mile producers and other small-scale participants in the supply chain must be integrated**. One major obstacle in this regard is that, for many participants, there simply isn't enough incentive to make the sometimes-considerable efforts to contribute. How, for example, can we entice farmers to install IoT sensors tracking soil conditions on their farms? To onboard more stakeholders across the entire food supply chain, there should be **a strong value proposition for all participants**.

In some of the early prominent blockchain-based FSCM initiatives, however, rather than providing clear value-add to participants at all steps in the supply chain, the project leaders have instead relied on a punitive approach. Thus suppliers, if they wish to continue selling their produce to the retailer in charge of the initiative, must adhere to the new procedures, as in Walmart's demand that all suppliers of leafy greens implement the new reporting procedures to trace their products all the way back to the farm by a deadline of September 2019.[47]

From the perspective of small producers and upstream suppliers, it may be that the prospect of losing a big buyer like Walmart or Carrefour is sufficient incentive to drive them to join the system. While this approach may ulimately prove effective for networks created by the largest retailers, it certainly doesn't do them any favors in terms of rapidly growing network adoption.

This is part of the reason that fully six months after IBM's Food Trust went live, project director Suzanne Livingston was only able to offer vague platitudes like,

> *"I have this vision that I want some farmer who only has these two fields but we care deeply about them, that they be able to just use their smartphone and do something quick for tracing."*[48]
>
> *— Suzanne Livingston, project director IBM Food Trust*

Sustainable delivery on Livingston's "vision" over the long term is yet to be proven, and forcing behavior change and expense as an entry cost might backfire.

Indeed, many companies who have announced plans to integrate IBM's blockchain-supported FSCM system over the past several years are still in the early testing phases of rolling out the blockchain for their supply chains.

In the case of Albert Heijn's blockchain initiatives as well, engaging all stakeholders in the supply chain proved a considerable challenge. In addition to its orange juice and egg tracing systems, Albert Heijn attempted to integrate blockchain-supported FSCM for its entire transport network. Unlike the orange juice and egg tracing systems, however, Albert Heijn's transport network did not survive past the proof-of-concept stage. The main reason, according to Albert Heijn IT specialist Marcel Yska, was that it was too difficult to onboard the large number of carriers.[49]

Challenge 2: Integrate data from disparate systems

To truly enable traceability, a complete FSCM system must also have **the capacity to integrate data from a wide variety of sources and standards.** In the implementation of blockchain-supported FSCM systems, the early pilots consistently showed that this was a challenge.

In Albert Heijn's case, for instance, the rollout of the blockchain system to participants faced challenges relating to linking different systems, but once that work was complete, maintenance of the system required hardly any extra work.[50]

Challenge 3: Rapidly develop and deploy blockchain-supported solutions

Few organizations are technologically sophisticated enough to develop and deploy blockchain solutions from scratch. As a relatively new and still emerging technology, there is currently a **shortage of qualified blockchain developers**. The tendency, then, is for organizations to rely on **one-size-fits all enterprise solutions** like IBM's Food Trust, which may not be ideal for the specific use case. For organizations looking to develop more customized solutions in-house, the cost of development can be prohibitively high and time to completion prohibitively long; both factors that considerably raise the risk of failure.

Meeting the challenges

Solution 1: Form a consortium

When it comes to the challenge of **engaging all stakeholders in a supply chain**, forming a large enough consortium may provide the critical mass needed to attract a wide enough group of stakeholders to make the project sustainable in the long term. Walmart's initial consortium-building effort, for instance, formed the core of what is now known as IBM's Food Trust. The IBM Food Trust now counts more than 200 companies as members, including some of the biggest food suppliers and food retail outlets in the world such as Albertsons, Tyson, Nestle, Dole, and Carrefour. By April 2019, at least 500,000 traces had been conducted on the platform, with each trace representing a single lot.[51]

Solution 2: Incentivize first-mile producers

An approach focusing on **delivering value** to the entry points at the farm(er) level will require more **tangible benefits** for these farmers to buy in for the long term. The following are some examples of solutions deployed thus far.

Direct communication

One attempt at incentivization of farmers to participate that is showing early success is with Albert Heijn. They have enabled a functionality in their consumer app that allows end-consumers to not only see and verify the provenance trail of their orange juice, but to also communicate with the farmers that provided the oranges in their orange juice and to "tip" them for their efforts by sending personalized messages through the system's "Like2Farmer" feature. Enabling actual monetary tips (rather than just messages) would likely provide greater incentive but this gamification and true peer-to-peer exchange element may go a long way to creating incentives sufficient for farmers to be fully on board.

AB InBev

Data driven insights

Pooling and analyzing data generating by first-mile producers can reveal insights that help improve productivity, raise profitability, and reduce environmental footprint. **Providing these insights to first-mile producers can serve as a powerful incentive to have them join the network and contribute their data.** This is one of the goals of the SettleMint-backed AB InBev pilot currently underway in Europe.

AB InBev - the world's leading brewer with over 200 brands including Budweiser, Corona, and Stella Artois - has a farmer base of around 35,000 growers across 13 countries and five continents. As part of its Smart Agriculture initiative, AB InBev already works directly with about 60% of these farmers to support agronomy skills and provide tools, research, and financing towards improving productivity, profitability, and sustainability. AB InBev was recently recognized in Fortune Magazine's Change the World 2020 ranking for this work.

Now, AB InBev partnered with Fujitsu and SettleMint to pilot a blockchain-supported FSCM system that targets the remaining 40% of its farmer base, many of whom are located in European countries such as France, Russia and the UK.

Similar to many of the FSCM initiatives described in this report, the pilot – which leverages SettleMint as the blockchain technology solution provider - is enabling **full transparency and traceability in the supply chain**. In this case, the supply chain for beer starts with barley. Consumers who purchase beer at the store can scan a QR code to learn about where the barley in their beer is grown. In a world where consumers are increasingly concerned about issues like sustainability, fair trade, and environmental impact, this is an important marketing advantage.

> *"This new barley blockchain pilot is the latest initiative in our focus on smart agriculture: using new technology, data and insights to improve our farmers' use of natural resources, crop yields and livelihoods."*
>
> *— Erik Novaes, Vice President of Procurement & Sustainability, Europe at AB InBev*

The difference with the AB InBev pilot, however, is that a core objective of the pilot is to assist first-mile producers by improving their yields, water & energy efficiency, and soil health.

Better prices

For many stakeholders in the food supply chain, direct monetary incentives are likely to be a significant driver of adoption.

One example of a pilot which attempted to integrate **direct monetary incentives** to first-mile producers was Trado, a blockchain-based FSCM solution developed by a consortium of international banks, corporates, fintech startups, an NGO, and a research institution created. The Trado pilot enabled a "**data-for-benefits swap**" between buyers and suppliers in the supply chain for tea. In the fully realized version of Trado's platform, blockchain and smart contracts could theoretically be used to collect and record social and ecological data from first-mile suppliers, who in return can get better prices for their goods and preferential access to low-rate trade finance. This model shows promise as a method for ensuring sustainability goals are met but, as demonstrated by a pilot conducted in early 2019, Trado's solution also highlights the challenges in pulling it off.

TYPICAL SUPPLY CHAIN SHOWING THE TIME PERIOD BETWEEN 'BILL OF LADING' AND 'PURCHASE ORDER' TRUST POINTS FOR MALAWI

source: https://medium.com/@provenance/project-trado-redistributing-the-rewards-c8e65c9dce8a

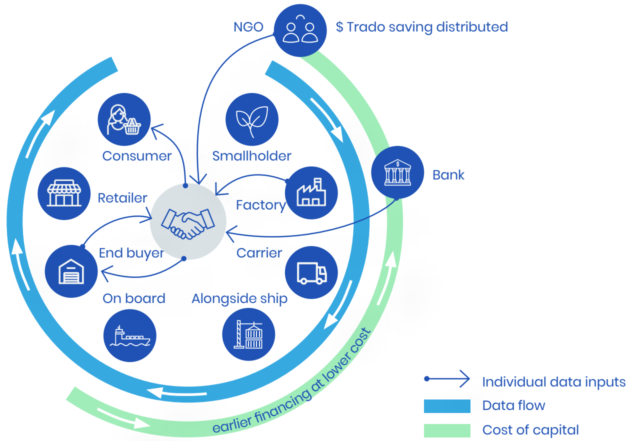
Trado conducted a pilot of the platform in early 2019, testing its efficacy in the **supply chain of tea from Malawi to global markets**. In line with Trado's vision to support sustainability, one of the key goals of the pilot was to enable smallholder tea farmers who have been identified with a higher "sustainability score" to get a significantly better price for their tea. Due to local price fixing for green tea leaf from farmers in Malawi, however, Trado was unable to achieve that goal.[52] This illustrates **the importance of aligning more stakeholders** in the supply chain. If, for example, the main purchaser of green tea leaf from smallholders (in the case of Malawi it was Lujera Tea Estates) could be convinced of the benefits of eliminating the price fixing (which would ultimately be more profit for all), the price variability needed to directly benefit smallholders who are more sustainable could have been unlocked.

Although the pilot was unable to provide direct economic incentives to smallholder farmers, the data gathered on the farmers nevertheless provided **indirect benefits for all stakeholders**, including farmers. In the pilot, a data collection company was tapped to gather the needed information on individual smallholder tea farmers. The information, which was verified by a local NGO, included demographic data like level of education, economic data like type of transport used, financial data such as savings and borrowing methods, and agricultural data such as farming practices. A buyer could leverage that data by making it available to prospective shoppers to increase sales, as in many of the examples described above. Secondly, a buyer could use the data to prove to regulators that it is compliant with environmental and labor standards. In both cases, the benefits could potentially trickle down to first-mile producers.

Trade financing

Despite its inability to directly impact smallholder tea farmers, Trado's Malawi pilot did demonstrate an important proof of concept in the sense that it managed to enable **much improved coordination** between a tea factory in Malawi, its direct buyer (Unilever), and a financier (BNP Baribas). This was achieved, in much the same manner as projects in the sector, **by leveraging blockchain technology to share in real-time the relevant data amongst the permissioned stakeholders**. In this case, the relevant data included production data like quality, quantity, date, price and sample approvals, as well as shipping data. The stakeholders included a factory, a buyer, and a financer. Because Unilever (the buyer) was able to see the contract being fulfilled in real time, it was prepared to take the risk of providing a payment obligation to its bank (BNP Baribas) before the goods had even left the factory. The tea factory, in turn, was therefore able to receive supply chain financing 35 days earlier than it would have under traditional supply chain management conditions. In the period between producing the goods and those goods being boarded, a supplier would normally need to rely on more expensive local financing. In this case, the supplier received the financing before the goods even left the factory. The savings made by the factory in this regard were recorded publicly on the blockchain and reinvested in sustainability initiatives in the farming community, with investments also tracked on the blockchain.[53]

SMALLHOLDER AND PROCESSOR AGREE TO MAKE DATA VISIBLE. BASED ON VISIBILITY, END-BUYER HAS CONFIDENCE TO INSTRUCT BANK TO RELEASE MONEY EARLIER.



source: https://provenance-storage.s3.eu-west-2.amazonaws.com/resources/Trado+New+technologies+to+fund+fairer-+more+transparent+supply+chains.pdf

A cost-effective and user-friendly platform

The Geora platform, developed by Australian blockchain startup AgriDigital, is an example of a solution that delivers a cost-effective, user-friendly package that represents a sufficient enough value-add for smallholders to merit their joining. AgriDigital first executed the settlement of the sale of grain on a blockchain in a 2016 pilot.[54] Since then, AgriDigital's blockchain-powered solution has expanded in scope and usage. Farmers now have the ability to manage payment terms and transfer ownership using a mobile app, which also lets them receive live notifications about payments and quantity and quality of deliveries. For smallholder farmers in developed nations, this type of solution shows **promise for increasing first-mile engagement**. It has also proven effective for other supply chain participants. Traders, for instance, can use AgriDigital's app to create and receive "deliveries onto contracts, orders, and inventory positions with real time valuations and live position updates." Additionally, buyers can upload cash bids and be updated in real time as they are filled. AgriDigital's grain tracking and trading system currently has over 4,000 active users with 11.4 million tonnes of grain, worth more than AUS $2 billion, having been transacted.[55]

Carrefour

Solution 3: Develop and deploy quickly

SettleMint has been very active in the food supply chain use case for blockchain. A large part of our success so far is due to our **middleware solution** having the capacity to deploy in the real world at a much faster rate than well-known competitors like the IBM Food Trust. For instance, while the testing alone for IBM's Carrefour France project took 18 months, we were able to test and deliver a similar solution for Carrefour Belgium in under three months.

> *SettleMint was basically like Lego for us. It allowed us to quickly implement blockchain technology in the Vinçotte meat tracing app for Carrefour in one weekend and a couple of days testing.*
>
> *— Jonas van Hove, Innovation manager at Vinçotte*

Our solution for that project, which was developed in collaboration with Belgian inspection body Vinçotte, enabled the tracking of Carrefour Belgium's pork through the use of QR codes affixed to products at packaging. The code is scanned along the supply chain, with data stored in a blockchain deployed amongst and verified by supply-chain participants. Belgian inspection body CEO Marco Croon commented on the project in early 2019: "*The application will enable stakeholders to react more quickly and even more accurately to potential problems in the supply chain, thus ensuring better overall food security.*"[56] Carrefour, for its part, saw increased sales of its blockchain-enabled 'Porc d'antan' which is part of its Filière Qualité range.

source: https://actforfood.carrefour.eu/fr/nos-actions/Acte-19

Solution 4: Focus on interoperability with existing FSCM infrastructure

Fujitsu-backed Switzerland/Singapore-based startup Rice Exchange (Ricex) is a **trading platform built on Hyperledger Fabric**, a permissioned version of the public Ethereum blockchain. Ricex is an example of blockchain-enabled FSCM infrastructure that identifies and focuses on interoperability with existing FSCM infrastructure as a key to onboarding the necessary stakeholders.

The $450 billion global rice trade is a notoriously opaque and process-intensive system. Not only do certification requirements for rice imports vary by region (with the need for documents to be checked and matched manually) but, compared to other staple crops, there are a wide variety of types and finishes for rice. This makes the pricing of rice more complex than other staple crops. Consequently, trading of rice globally, which has increased five-fold over the last 30 years to become the world's largest agricultural commodity, is managed by "a relatively small group of individuals, with little transparency" according to a report from Fujitsu.[57] All of these factors make rice trading an ideal use-case for a blockchain-supported system. As with other blockchain-supported supply-chains, it does this by **creating a real-time view for all stakeholders of verified, immutable data**.

According to Head of the Brussels-based Fujitsu Blockchain Innovation Center Frederik De Breuck, a key to enabling the success of the Ricex platform is ensuring the blockchain component of the project interoperates with existing infrastructures:

> *"Ricex has shown great vision in adopting Fujitsu's approach to distributed ledgers as a supplementary layer in larger enterprise architectures, and not as end-to-end solutions by themselves. We have placed a focus on making sure the DLT can interoperate with existing infrastructures. This is how we deliver true value from investment in this exciting new technology."*
>
> *— Frederik De Breuck, Head of Fujitsu Blockchain Innovation Center [58]*

Demonstrating **its ability to facilitate interoperability with existing infrastructure**, since launching in November in 2019, Ricex has successfully onboarded several ecosystem participants, the addition of each of which contributes to the strength and utility of the platform as a whole. These participants include a leading shipping service focused on the important rice route between Asia and West Africa, an insurance company who offers a dedicated marine insurance policy, an ecolabel and assurance provider (enabling the verified certification of sustainably produced rice), and an inspection and certification company.

CONCLUSION

Many of the problems in status quo FSCM can indeed be solved by blockchain-supported solutions. These solutions represent a significant improvement over the traditional IT solutions deployed in the first decades of the century.

The key challenges are integrating blockchain-enabled solutions with already existing IT solutions, deploying a solution in a timely and cost-effective manner, and engaging the wide and varied stakeholders in the ecosystem, from smallholder farmers to medium-sized processors, transportation companies, retailers, and finally consumers. All of these challenges are best overcome through active dialogue and a "feet on the ground" approach to informing all stakeholders of the benefits of the blockchain-enabled solution.

Highlighting to stakeholders the potential of blockchain-enabled solutions to support sustainable development goals is one important strategy for achieving "buy in." On the technical side, getting data models aligned amongst stakeholders is an important part of the solution. Offerings which integrate most or all of the five above-listed "Solutions" are likely to gain traction more quickly and achieve wider adoption.

Ultimately, if enough stakeholders can be incented to join by providing clearly apparent value-add and, if necessary, boosts through government- or NGO-supported initiatives, the real power of these decentralized networks can be unleashed on the food supply chain. The result should be tangible improvements in FSCM with real benefits for all stakeholders.

END NOTES

1. Füzesi, István & Lengyel, Peter & Robert, Szilagyi & Ráthonyi, Gergely. (2016). APPLICATION OF EDI TECHNOLOGIES IN THE FOOD SUPPLY CHAINS. Journal of EcoAgriTourism. (page 33)

2. Cutler, Thomas R. (2018 June 25). "Track and Trace for Small Food Manufacturers." Food Quality & Safety. (Paragraph 2).
Retrieved from: https://www.foodqualityandsafety.com/article/track-and-trace-small-food-manufacturers

3. Gaur,Vishal and Gaiha, Abhinav. (2020 May-June). "Building a Transparent Supply Chain." Harvard Business Review Magazine.
Retrieved from: https://hbr.org/2020/05/building-a-transparent-supply-chain

4. Godbole, Shantanu (2017). How Blockchain can transform Global Trade Supply Chains. IBM Center for Blockchain Innovation IBM Research, IBM Academy of Technology. (page 9).
Retrieved from https://www.unescap.org/sites/default/files/3_IBM%20Blockchain.pdf

5. Mearian, Lucas. (2018, January 16). "Maersk, IBM create world's first blockchain-based, electronic shipping platform." Computer World.
Retrieved from: https://www.computerworld.com/article/3247758/maersk-ibm-create-worlds-first-blockchain-based-electronic-shipping-platform.html

6. Allison, Ian. (2017, March 8). "Maersk and IBM want 10 million shipping containers on the global supply blockchain by year-end." International Business Times.
Retrieved from: https://www.ibtimes.co.uk/maersk-ibm-aim-get-10-million-shipping-containers-onto-global-supply-blockchain-by-year-end-1609778

7. Mcentire et al. (2010). Traceability (Product Tracing) in Food Systems: An IFT Report Submitted to the FDA, Volume 1: Technical Aspects and Recommendations. Comprehensive Reviews in Food Science and Food Safety. 9. 67. 10.1111/j.1541-4337.2009.00097.x. (page 120)

8. Ibid. Page 119-121.

9. Centers for Disease Control and Prevention. (2009, May 11). "Multistate Outbreak of Salmonella Typhimurium Infections Linked to Peanut Butter, 2008-2009 (FINAL UPDATE)."
Retrieved from: https://www.cdc.gov/salmonella/2009/peanut-butter-2008-2009.html

10. World Health Organization. (2020, April 30). "Food Safety." WHO News Room Fact Sheets.
Retrieved from: https://www.who.int/news-room/fact-sheets/detail/food-safety

11. World Health Organization. (2015, March 12) "More than 23 million people in the WHO European Region fall ill from unsafe food every year". WHO Regional Office for Europe.
Retrieved from: https://www.euro.who.int/en/health-topics/disease-prevention/food-safety/news/news/2015/12/more-than-23-million-people-in-the-who-european-region-fall-ill-from-unsafe-food-every-year

12. Sufiyan, Mohd & Haleem, Abid & Khan, Shahbaz & Khan, Mohd Imran. (2019). Analysing Attributes of Food Supply Chain Management: A Comparative Study. 10.1007/978-981-13-6412-9_50. Page 516

13. Blanchfield, J.R., and B. Welt, "Food traceability," The International Union of Food Science and Technology, March 2012.
Retrieved from: www.iufost.org/iufostftp/IUF.SIB.Food%20Traceability.pdf (page 6 and 7)

14. Produce Processing. (2007, March 23). "FDA Finalizes Report On 2006 Spinach Outbreak."
Retrieved from: https://produceprocessing.net/news/fda-finalizes-report-on-2006-spinach-outbreak

15. Arnade, Carlos. (2010, March 1). "Consumers' Response to the 2006 Foodborne Illness Outbreak Linked to Spinach." Economic Research Service, United States Department of Agriculture.
Retrieved from: https://www.ers.usda.gov/amber-waves/2010/march/consumers-response-to-the-2006-foodborne-illness-outbreak-linked-to-spinach

16. Ibid.

17. Mohr, Angie. (2019, Jun 25). "The 5 Largest Food Recalls in History." Investopedia.

Retrieved from: https://www.investopedia.com/financial-edge/0512/the-5-largest-food-recalls-in-history.aspx

18. Zafar, Amina. (2019, Nov 26). "Why E. coli linked to romaine lettuce remains 'an extremely difficult problem'".

Retrieved from: https://www.cbc.ca/news/health/romaine-lettuce-e-coli-food-safety-1.5372926

19. Sample, Ian. (2011, June 10). E coli outbreak: German organic farm officially identified.

Retrieved from: https://www.theguardian.com/world/2011/jun/10/e-coli-bean-sprouts-blamed

20. Burger R. EHEC O104: H4 IN GERMANY 2011: LARGE OUTBREAK OF BLOODY DIARRHEA AND HAEMOLYTIC URAEMIC SYNDROME BY SHIGA TOXIN–PRODUCING E. COLI VIA CONTAMINATED FOOD. In: Institute of Medicine (US). Improving Food Safety Through a One Health Approach: Workshop Summary. Washington (DC): National Academies Press (US); 2012. A1.

Available at: https://www.ncbi.nlm.nih.gov/books/NBK114499

21. Karthikeyan V. and Garber A. (2019, Jan). "How Safe is Our Food? Recent trends and case studies, and what they mean for our health." US Public Interest Research Group Education Fund. (page 12 – 13)

Retrieved from: https://uspirg.org/sites/pirg/files/reports/WEB_USP_Safe-Food-Report_Jan19.pdf

22. According to global law firm Clyde & Co from its analysis of EU data, including the RAPEX alert system, RASFF Portal, and annual reports, as reported in "Increase in EU food recalls" (2018, Feb). Food Management Today.

Retrieved from: https://www.foodmanagement.today/increase-in-eu-food-recalls

23. According to a 2017 study by the Food Marketing Institute and the Grocery Manufacturers Association (GMA), as reported in Wood, Harry (2017, July) "The cost of product recalls to food businesses" in Rentokil blog,

Retrieved from: https://www.rentokil.com/blog/cost-of-product-recalls/#.Xj9VNGgzaUk

24. Grocery Manufacturers Association (2011). "Capturing Recall Costs Measuring and Recovering the Losses."

Retrieved from: https://cdn2.hubspot.net/hub/288450/file-606071909-pdf/Capturing_recall_costs.pdf

25. World Economic Forum. (2013, January). "Building Resilience in Supply Chains: An Initiative of the Risk Response Network." (page 3).

Retrieved from: http://www3.weforum.org/docs/WEF_RRN_MO_BuildingResilienceSupplyChains_Report_2013.pdf

26. PwC. (2016, January 14)."Fighting $40bn food fraud to protect food supply,"

Retrieved from: https://www.pwc.com/my/en/press/160127-fighting-40bn-food-fraud-to-protect-food-supply.html

27. Kamath, Reshma. (2018). Food Traceability on Blockchain: Walmart's Pork and Mango Pilots with IBM. The Journal of the British Blockchain Association. 1. 1-12. 10.31585/jbba-1-1-(10)2018. (page 2)

28. Fortune, Aidan. (2018, July 6). "Food Safety Survey 2018: The Results." Food Manufacture.

Retrieved from: https://www.foodmanufacture.co.uk/Article/2018/07/05/Food-safety-survey-results

29. European Commission (2016), "Food and drink industry", Growth Internal Market, Industry, Entrepreneurship and SMEs,

Available at: https://ec.europa.eu/growth/sectors/food_en

30. Buterin, Vitalik (2017, February 7). "The Meaning of Decentralisation." Medium.com/@VitalikButerin/.

Retrieved from: https://medium.com/@VitalikButerin/the-meaning-of-decentralization-a0c92b76a274

31. Hill, Craig & Scudder, Gary. (2002). The Use of Electronic Data Interchange for Supply Chain Coordination in the Food Industry. Journal of Operations Management. 20. 375-387. 10.1016/S0272-6963(02)00017-7. (page 383)

32. Füzesi, István & Lengyel, Peter & Robert, Szilagyi & Ráthonyi, Gergely. (2016). APPLICATION OF EDI TECHNOLOGIES IN THE FOOD SUPPLY CHAINS. Journal of EcoAgriTourism. (Page 37.)

33. Hill, Craig & Scudder, Gary. (2002). The Use of Electronic Data Interchange for Supply Chain Coordination in the Food Industry. Journal of Operations Management. 20. 375-387. 10.1016/S0272-6963(02)00017-7. (page 383).

34. Ibid.

35. Yiannas Frank. (2018) A New Era of Food Transparency Powered By Blockchain. Innovations: Technology, Governance, Globalization, 12(1-2), 46–56. doi: 10.1016/j.trac.2018.08.011. (page 51).

36. Ibid. (page 53).

37. Ibid.

38. Ibid.

39. Ibid. (page 55).

40. Smith, Matt (2018, September). "In Wake of Romaine E. coli Scare, Walmart Deploys Blockchain to Track Leafy Greens" Walmart Corporate Newsroom.

Retrieved from: https://corporate.walmart.com/newsroom/2018/09/24/in-wake-of-romaine-e-coli-scare-walmart-deploys-blockchain-to-track-leafy-greens

41. Thomasson, Emma. (2019, June 4) "Carrefour says blockchain tracking boosting sales of some products." Reuters.

Retrieved from: https://www.reuters.com/article/us-carrefour-blockchain-idUSKCN1T42A5

42. Ibid.

43. Vitisphere. (2020, February 6). "How Carrefour demonstrates the traceability of its organic wine using blockchain technology."

Retrieved from: https://www.vitisphere.com/news-91229-How-Carrefour-demonstrates-the-traceability-of-its-organic-wine-using-blockchain-technology.html

44. Carrefour. "Action 9: The Food Blockchain."

Retrieved from: https://www.carrefour.com/en/group/food-transition/food-blockchain#:~:text=In%202019%2C%20Carrefour%20has%20gradually,Norwegian%20salmon%20and%20Christmas%20chicken

45. Naik, Gautam. (2019, Jan 11). "Companies use blockchain to track food products from farm to fork." S&P Global Market Intelligence.

Retrieved from: https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/companies-use-blockchain-to-track-food-products-from-farm-to-fork-49267094

46. Refresco. (2018, September 20). "Albert Heijn and Refresco make orange juice supply chain transparent."

Retrieved from: https://www.globenewswire.com/news-release/2018/09/20/1584829/0/en/Albert-Heijn-and-Refresco-make-orange-juice-supply-chain-transparent.html

47. Smith, Matt (2018, September). "In Wake of Romaine E. coli Scare, Walmart Deploys Blockchain to Track Leafy Greens" Walmart Corporate Newsroom.

Retrieved from: https://corporate.walmart.com/newsroom/2018/09/24/in-wake-of-romaine-e-coli-scare-walmart-deploys-blockchain-to-track-leafy-greens

48. As quoted in in Allison, Ian. (2019, April). "World's Second-Largest Grocer Joins IBM Food Trust Blockchain."

Coindesk: https://www.coindesk.com/worlds-second-largest-grocer-joins-ibm-food-trust-blockchain

49. de Jong, Maurice (2020, January 20). "Blockchainexpert Albert Heijn: 'De businesscase om blockchain te gebruiken is niet echt sterk'" vmt.

Retrieved from: https://www.vmt.nl/duurzaamheid-mvo/nieuws/2020/01/blockchainexpert-albert-heijn-de-businesscase-om-blockchain-te-gebruiken-is-niet-echt-sterk-10139857

50. de Jong, Maurice (2020, January 13). "Refresco toont ambitie: mogelijk meer sappen in blockchain, andere supermarkten mogen aansluiten." Vmt.

Retrieved from: https://www.vmt.nl/duurzaamheid-mvo/nieuws/2020/01/refresco-toont-ambitie-mogelijk-meer-sappen-in-blockchain-andere-supermarkten-mogen-aansluiten-101396857_ga=2.237032320.1495236830.1606115385-1701052562.1606115385

51. According to information found in Allison, Ian. (2019, April). "World's Second-Largest Grocer Joins IBM Food Trust Blockchain."

Coindesk: https://www.coindesk.com/worlds-second-largest-grocer-joins-ibm-food-trust-blockchain

52. University of Cambridge Institute for Sustainability Leadership (CISL). (2019). Trado: New technologies to fund fairer, more transparent supply chains. Cambridge:University of Cambridge Institute for Sustainability Leadership. (page 9)

53. University of Cambridge Institute for Sustainability Leadership (CISL). (2019). Trado: New technologies to fund fairer, more transparent supply chains. Cambridge:University of Cambridge Institute for Sustainability Leadership. (page 31).

54. ICT4Ag. (2017). "Perspectives for ICT and Agribusiness in ACP countries: Start-up financing, 3D printing and blockchain."

Retrieved from: https://s3-eu-west-1.amazonaws.com/cta-scr-media/91e974bc-eebe-4558-ba02-fe0006606bbf.pdf

55. According to data from AgriDigital's website: https://www.agridigital.io

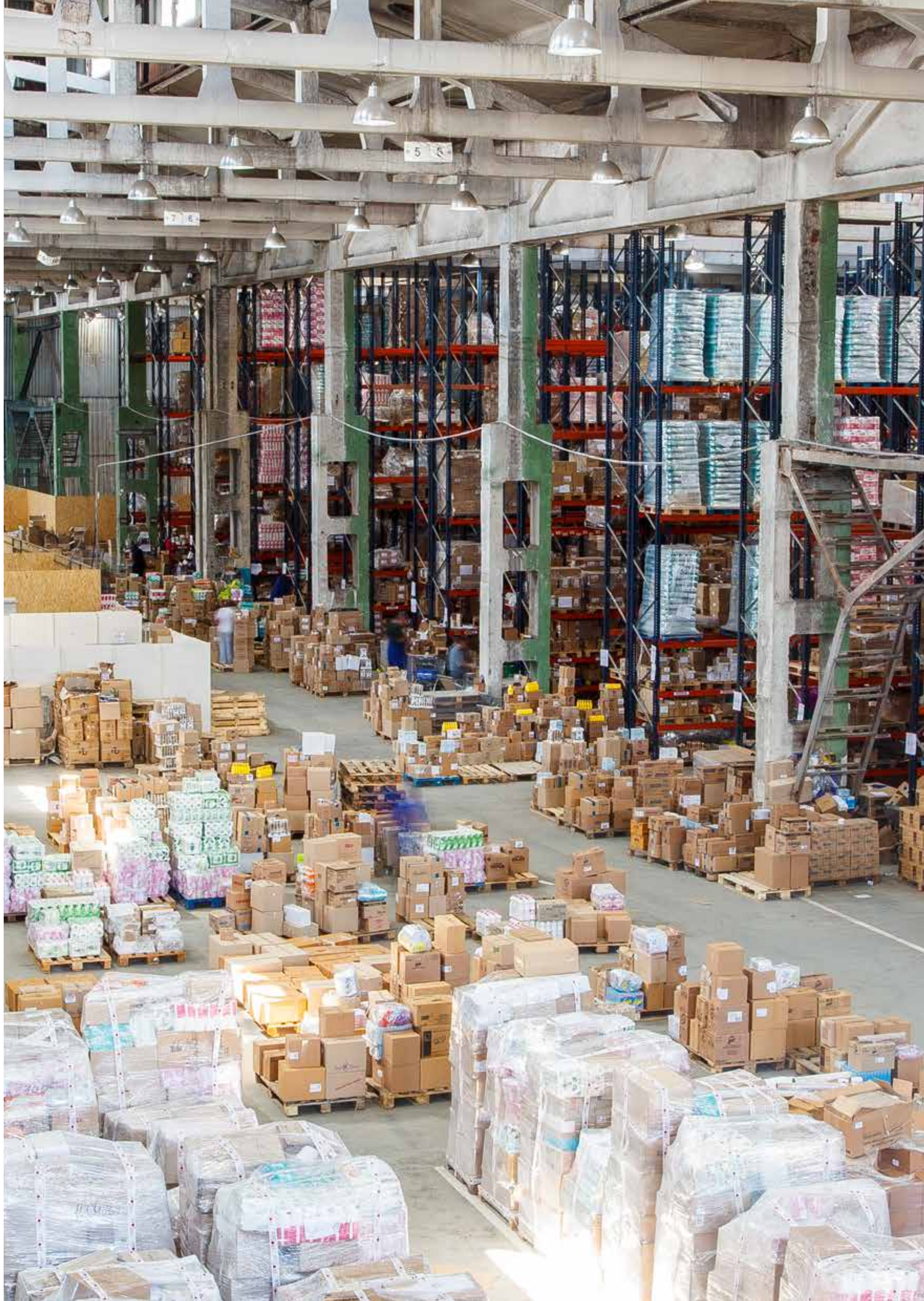
56. Thompson, Scott (2019, Feb 2) "Carrefour brings blockchain tech to Belgium and Italy."

Retrieved from: https://coinrivet.com/carrefour-brings-blockchain-tech-to-belgium-and-italy

57. Fujitsu. (2019, November 5). Fujitsu and Rice Exchange Bring to Market First Global Blockchain Rice Trading Platform.

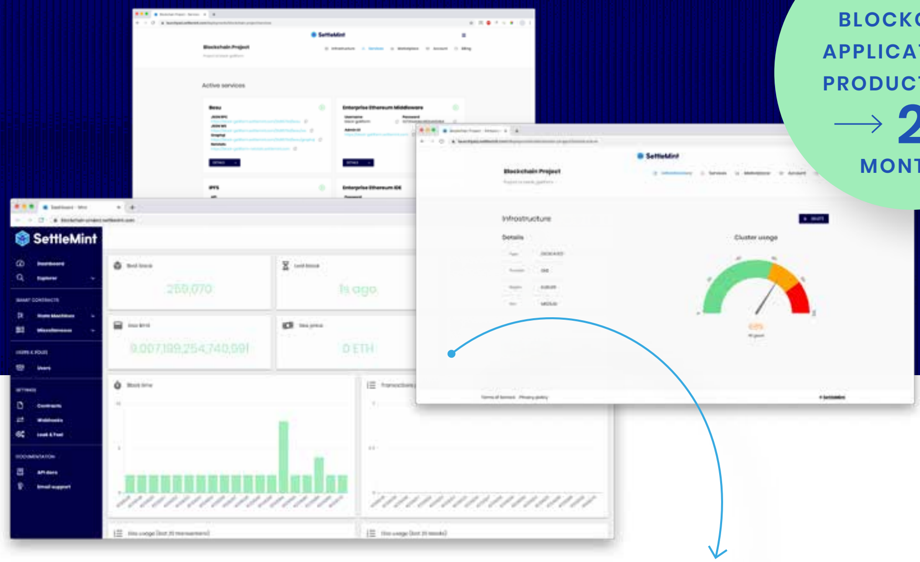
https://www.fujitsu.com/emeia/about/resources/news/press-releases/2019/emeai-20191105-fujitsu-and-rice-exchange-bring-to-market.html

58. Ibid.



SettleMint

THE #1 LOW-CODE PLATFORM FOR ENTERPRISE BLOCKCHAIN APPLICATIONS



YOUR BLOCKCHAIN APPLICATION IN PRODUCTION IN → 2 ← MONTHS!

- One-click deployment
- Zero-config admin UI
- No-code Integration Studio
- Ready to use APIs
- Smart contract templates
- Integrated Development Environment

Matthew Van Niekerk
Founder & CEO SettleMint
matthew@SettleMint.com

"Blockchain-supported Consumer Goods Supply Chain has emerged as a proven solution for increasing transparency and efficiency, and for supporting sustainability goals. Further, since network effects amplify many of the benefits, as the technology becomes more widely deployed, its utility will grow exponentially. As the premier low-code blockchain-as-a-service platform, SettleMint enables organisations to go from concept to in-production solution in weeks. Using SettleMint's tools, organisations can rapidly develop powerful Consumer Goods Supply Chain solutions that bring real value add, allowing them to have a transformative impact on Consumer Goods Supply Chain."

SettleMint