

CHAIN REACTIONS

THEMATIC BRIEF BIOECONOMY 2

BLOCKCHAINS IN THE BIOECONOMY

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ABOUT INNOVATION BRIEFS

CHAIN REACTIONS addresses the challenge for industrial regions to increase regional capacity to absorb new knowledge and turn it into competitiveness edge and business value. There is a strong need to help SMEs to overcome capacity shortages for innovation and integration into transnational value chains.

The project aims at empowering regional ecosystems with the knowledge and tools to help businesses overcome those barriers and generate sustained growth through value chain innovation. During the project lifetime the project publishes thematic briefs presenting the rationale behind specific innovation deployment within selected business areas.

This new brief of the CHAIN REACTION project presents the smart contract revolution, and the related technological state of the art and looks at its application in the bioeconomy area. We already discussed specifically about the blockchain technology exploitation with particular focus on the security aspects in the software industry in a previous thematic brief. This new brief is now dealing with the overall supply chain optimisation and efficiency that blockchain and smart contract approaches, and technologies could allow in the whole industry and more specifically in the bioeconomy.

BLOCKCHAIN AND THE BIOECONOMY

Supply Chain challenges

Although there have been many related research and studies to resolve issues arising from lack of trust in supply chain, it is still a difficult problem. The reason is that a traditional centralized trust mechanism cannot completely solve these three challenges [1]:

- 1) Self-interests of the supply chain members.
- 2) Information asymmetry in the production process.
- 3) Cost of quality testing and technical limitations.

A typical misconception is that traceability is only a numeric code attached to products, that it actually means place of origin, or that it is a method to ensure that information about the product is true. In fact, a lot of information goes up to through a supply chain, but this flow of information is usually not sufficiently used in the reverse direction to direct the supply chain in the sense of effective adaptive control [2]. Real-time data collected at the frontline should be used for directing the whole supply chain. In order to do so, all actors in a supply chain should have access to knowledge, normalizing information leverage during negotiations and providing more information about component origins and processes in order to reduce costs and improve performance of the chain.

The lack of reliable information transparency can cause:

- cost and customer relationship issues, which can negatively influence a brand name.
- various types of risks for company's processes (e.g. fraud and code of conduct)



violations.

- difficulties to respond to sudden demand changes on an increasing frequency.

These significant risks and difficulties are increasing as complex supply chains that are continuously extending variability risks. Hundreds of years ago supply chains were simple. Mines and farms provided natural resources to skilled craftsmen who then created and sold finished products. Today's supply chains are much more complicated and fragmented.

At different levels, businesses strive to deploy transparency, fair trade and sustainability. Supply chain transparency drives the adoption of socially responsible practices, since companies became more open to judgment by customers and fellow stakeholders. The adoptions of such practices create conditions that force competitors to match those same actions, especially for those with valuable, high visibility brand names. However, complex and non-integrated supply chain networks make it difficult to implement these principles.

In the bioeconomy, businesses have to address fair trade and sustainability issues that are taking an increasing role in customer purchasing decisions. But complex and non-integrated supply chain networks make it difficult to implement these principles.

Blockchain for Supply Chain Management

Supply Chain management (SCM) is a field where blockchain technology shows to be advantageous since this technology creates a platform where every player may access and share information, upon pre-existing rules.

Blockchain technology is able to remove the need for intermediaries and replace them with a distributed digital network. The users work in partnership to verify transactions and safeguard the integrity of the ledger. No need for centralised systems (a bank or some third party): every member of the blockchain network holds his own copy of the ledger or can access to the historic log of the system transactions and verify their validity, thus enabling a high level of transparency.

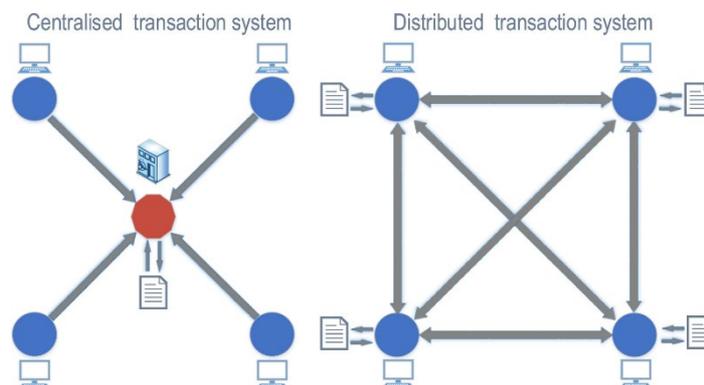


Figure 1 - Centralised vs. distributed transactional platforms [3]

The challenge then resides in finding an efficient way to consolidate and synchronise multiple copies of the ledger. The exact process of validation and ledger consolidation varies for different types of blockchains. However, in principle, network members compare their versions of the ledger through a process intuitively akin to distributed voting [4]. A consensus on the valid state of the ledger can then be reached. These validation mechanisms are known as distributed consensus algorithms.



Blockchain Process Steps

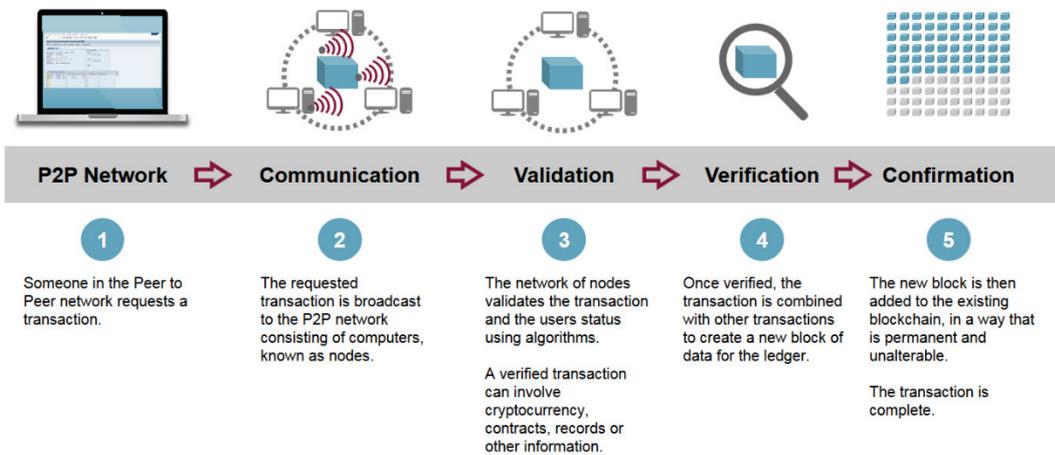


Figure 2 - Blockchain process steps [5]

At the end, blockchain technology could therefore transform the organisation of supply-chains, particularly in the bioeconomy area:

- This technology can offer product provenance tracking and record product status at each phase of its lifecycle. The system participants, including suppliers, manufacturers, couriers, and end-customers, are permitted to access this information, which helps to establish trust between them, predict many risks in the chain and even respond to sudden demand changes.
- Blockchain could help to reduce extra costs caused by fraud or product duplication, allows real-time product tracking, which helps significantly reduce the overall cost of moving an item in a supply chain. By strengthening the traceability, in situations such as product recalls or quality issues, companies can isolate a problem accurately, minimizing cost spend trying to locate its root cause.

If a powerful duo of Blockchain and the supply chain can help reduce errors, delays and eliminate fraudulent activities and even increase consumer/supplier trust, the benefits of Blockchain for the supply chain do not end here.

The smart contract revolution and challenges

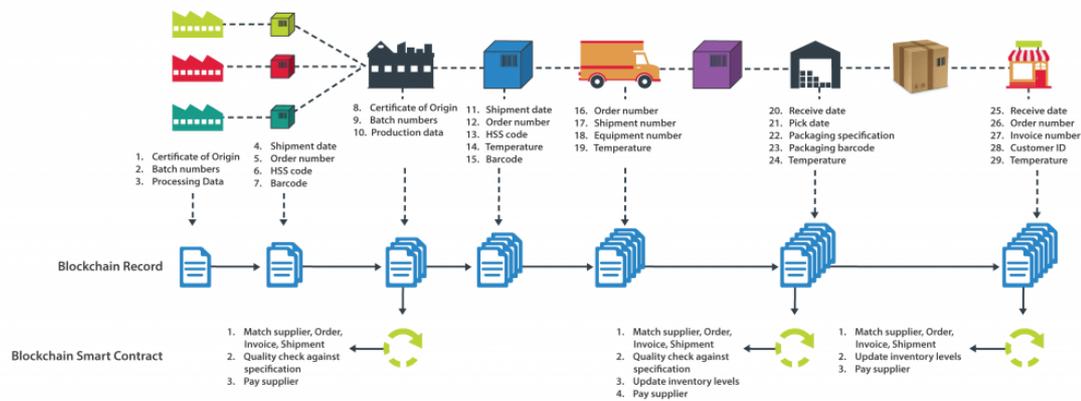
Blockchain technology is also starting to offer interesting opportunities for private transactions in the form of smart contracts, in fact, self-executing computer programmes.

Indeed, if someone decide to purchase a new phone and is concerned by the working conditions in the factory where the computer was assembled, he could have many difficulties to check where the phone really came from and how it has been made. Even the end vendor is usually not well aware about the complex supply chain that provide the materials, manufacture the components, assemble the parts and deliver the phone to market. Smart contracts can transform this process and make it visible to necessary parties.

A smart contract can be defined as a program powered by blockchain that carries out a digital contract. This contract can be digitally enforced, facilitated and verified thereby making it smart. This contract will function exactly as it has been programmed. No fraud



or other interference is possible. A smart contract like blockchain itself allows input from a ledger and can trigger an event when necessary. For example, if a payment has been received, the smart contract can trigger a delivery, however, if a condition has not been met, the smart contract can trigger a penalty or another action.



Example Blockchain with a Smart Contract [6]

Smart contracts can make supply chain management simpler and more transparent. Consider the impact that full visibility of a product's supply chain will give companies. Enabling them to know where parts have been sourced, what companies were involved in making the product and how it has moved from one end of the supply chain to the other. This allows companies to have full transparency and helps to strengthen partnerships between companies. The idea is to create a single source of information about a product in a supply chain via a global ledger. Each component has its own entry on the blockchain and can be tracked over time. Authorised companies then update the status of a component in real-time.

Tenderly – Smart Contract Monitoring

Various startups work on developing automation solutions for simplifying the monitoring of smart contracts in order to reduce the time spent on monitoring and analysis of contract details. Such systems allow the user to focus on the terms and conditions of various smart contracts in the blockchain. The Serbian startup Tenderly extracts real-time data from blockchain contracts with the help of a custom Ethereum Virtual Machine (EVM) [7]. This system allows users to set alerts and notifications when certain functions are brought into the contract. It can also alert when a blacklisted caller tries to get in touch with the contract. Their solution extracts blockchain data and analyzes it using customized visual graphs.

Superblocks – Smart Contract Deployment

The Swedish startup Superblocks automates the development process of blockchain applications and makes it more efficient [8]. Their automated smart contract development platform solutions minimize the need for technical blockchain expertise for the customers: users are then able to deploy transparent and self-executing contracts quickly and efficiently. They provide complex applications with all customizable scripts and procedures required to successfully develop and launch blockchain applications.



Agriculture and Food Industry

Many products in the food industry are susceptible and have specific needs. The product storage conditions, such as temperature, humidity, or vibration, can be recorded by sensors and stored on a Blockchain. If one of the parameters deviates from a norm, then it could be immediately tracked by all the Blockchain participants. In this case, a smart contract can automatically solve a problem by triggering needed actions.

Companies in this area already actively use RFID tags to store information about products in supply chains. Commonly, they are automatically processed by IT systems and used for smart contracts in logistics. RFID-tags for cartons or pallets preserve information about the location and date of delivery. Logistics partners use specific apps to search for these tags and bid for a delivery contract. The partner offering optimal price and service gains the deal and then a smart contract can monitor the status and final delivery performance.

Beyond the safety and traceability aspects in the context of food industry, blockchain has potential to help the agriculture space evolve. A decentralized blockchain system could improve transactions, market expansions, and product-specific logistics throughout the agriculture supply chain. In agriculture, a blockchain record could establish a level of trust between merchants who otherwise might not have experience with one another. It allows the market to expand and encourages healthy competition between sellers.

AgriDigital

One company, AgriDigital, is already using blockchain technology to digitize the buying, selling, and storing of grain, with plans to add other commodities [9]. This platform is a cloud-based, multi-participant commodity management platform. All players across the agricultural supply chain – farmers, buyers, storage operators, and in time, even consumers – can operate and interact on the platform for the transaction of their commodities.

Walmart - transparency to the decentralised food supply ecosystem

The world commercial giant Walmart has been working with IBM on a food safety blockchain solution to add transparency to the decentralised food supply ecosystem by digitising the food supply chain process [10]. They created a food traceability system based on Hyperledger Fabric. Anytime the company can access information about who has sold the meat and who has bought it. The system processes each step of its journey to a customer, and records everything in the supply chain up to the sale date. Each node on the Blockchain represents an entity that has handled the food on the way to the store. The identification of farms which has sold an infected batch is thus getting a lot easier and faster.

Fieldcoin - connecting landowners with crowdfunding investors

Fieldcoin is developing a platform using blockchain technology in order to connect landowners with crowdfunding investors, while enabling fast and cheaper transfers of land property to individuals and companies [11]. This world's first decentralised land property management marketplace is coordinated with a country's blockchain-based registry system in order to facilitate transactions between individuals. Its mission is to bring blockchain technology to land property transactions and agricultural crowdfunding projects while creating a stable transaction instrument using IoT, blockchain technology, 4.0 agribusiness technologies and crowdfunding.



Forestry

The most obvious benefit of Blockchain in the forestry industry is also supply chain transparency and management. Large, multinational supply chains in this area are built on numerous transactions and contract fulfilment. If you cut a tree in Finland, sell it to a broker, who then puts it in a pile to be shipped to Spain, which then gets distributed to a mill, then sold to a housing project in Paris. The layers of contracts and transactions is a real challenge, especially when considering timber trading laws, sustainability regulations and forest management practices.

Indeed, companies in this industry currently find it complex and challenging to verify the origin and sustainability of products including tissue, packaging, sawn goods and more. Wood certification is usually managed by third-party organizations and help with sustainability measurement and management (e.g. FSC [12]). But they are often costly, strict and irregular in their requirements. These constraints come on the top of already strict and also very various national forest legislations for certification, thus exacerbating competition between countries and regions.

This is currently for instance a big issue with palm oil and biodiesel in the EU: governments pay for bio-diesel, but they end up funding massive deforestation in Indonesia, Brazil and other places. Because of greed, lack of oversight and transparency. Using Blockchain technology, it could be possible to get all the needed information and evidence, without having to rely on another country's documentation. At the end, blockchain won't replace standards because good data are still needed. In the biodiesel case, the tracking could be used to get evidence that there was no land-use change when creating this bio-diesel or that biofuel.

Smart Forest – Blockchain based Forest investment

One of the main aims of the Smart Forest platform is the democratization of forest investment and the popularisation of trees as a very stable investment asset [13]. But to be a truly accessible asset for anyone it had to be also affordable. This is why they decreased the costs of hectares to the singular trees. Even investors with a very small investment wallet, can buy one tree per month and protect their financial future in a long-time perspective. Trees as an anti-speculative asset allow investors to preserve their capital during the turmoil times. Trees can grow over the financial or political crises. The objective is also to cooperate mainly with local, family companies.

Fishery

For companies that buy and sell seafood, the lack of product origin information and supply chain transparency can pose significant risks. In the past, industry's traceability focus was primarily on food safety concerns. However, the increase in media coverage about the environmental, social and legal issues associated with seafood has led to significant shareholder concerns, potential impacts on brand value, and challenges to the corporate social responsibility initiatives of companies. Trading is often tied up awaiting the manual processing of documents.

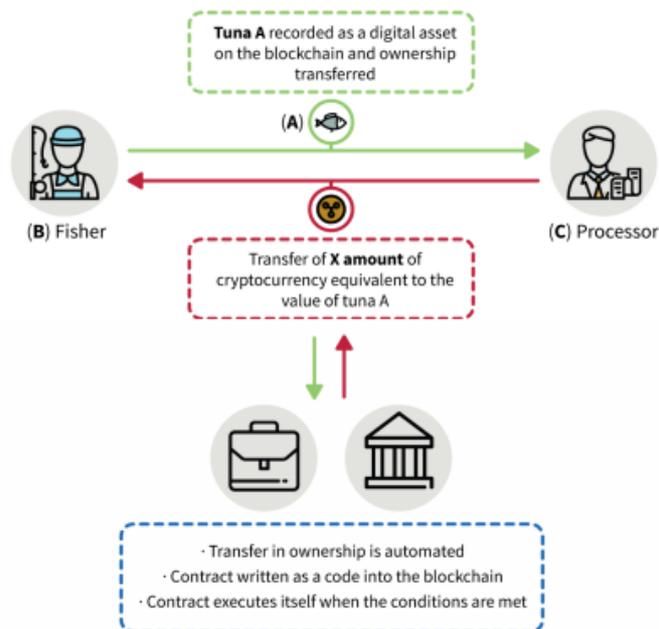


Figure 4 - An Example of a blockchain smart contract in seafood value chain [14]

Fishery trade involves lot of actors and still relies heavily on paper documentation for verification and authorization purposes. The coordination of multiple parties in the respective countries to share information with one another is also needed to ensure the movement of the products.

Traceability and transparency of sea products through complex value chains is challenging. Table 1 shows a typical fishery supply chain with the segments covered or controlled by the various roles of State involved. Few operations along the supply chain are usually under the exclusive purview of a single State. A large number of operations fall under the purview of different State along the supply chain.

Supply chain function	 Harvesting	 Trans-shipping	 Landing	 Transport to processing	 Processing	 Importation
 Costal State	✓	✓				
 Flag State	✓	✓	✓			
 Port State		✓	✓	✓		
 Processing State				✓	✓	
 End-market State						✓

Table 1 - Standardized supply chain with segments cover or control [15]

Blockchain, with its inherent characteristics of immutability, security and decentralization together with smart contract technologies, has the potential to improve efficiencies and accountability in fishery value chains.



Bitcliq - connecting fishermen with buyers and supply-chain traceability

Portuguese startup Bitcliq is the world's first blockchain marketplace for fish trading, connecting fishing fleets with buyers, and enabling the purchase of fish the moment they are caught at sea by retailers and restaurant owners. In addition to connecting fishermen with buyers, its platform also allows for complete traceability from catch location to table, which is becoming essential for an ecosystem with dwindling prospects because of illegal fishing practices and ocean pollution. Bitcliq raised €600k in February 2019 [16].

Deployment cost of the blockchain technology

In considering the use of blockchain solutions for value chains in the bioeconomy, it is important to be aware of the costs involved. Building a blockchain solution in this area from scratch can be very costly given the shortages in experienced blockchain developers and the fact that there are limited developers with deep knowledge of fishery, forestry or agriculture value chains. It might be easier to subscribe to an existing blockchain service or even to a dedicated blockchain traceability service without needing to make a huge investment. This option is also faster to set up and test the technology in a bioeconomy value chain.

The software integration costs also have to be carefully considered (for instance with existing ERP software). Hardware costs also need to be taken into account. This involves needed equipment like data capture devices (tablets, laptop computers, RFID scanners, ...) as well as tagging and label printing solutions. The overall communication infrastructure to maintain blockchains in near real time is also challenging and costly. Blockchains require intense and frequent communication between the nodes of the blockchain network. Receiving and sending large data volumes at sea, in the mountains or in any kind of scarcely populated isolated area might be only possible via satellite communication. Installing satellite communication devices may be not financially feasible in small-scale companies. Transmission prices could be too high and the available bandwidth still too narrow to support the needed information flow.

Conclusion

There are many ways blockchain that can help the bioeconomy industry and the blockchain presence in the bioeconomy is already undeniable. The demand for more efficient and effective traceability systems, in addition to consumers demand for transparency, already pushed this innovation in this large sector. Solutions are characterized by multi-stakeholder networks where supply chain information is available to designated entities. Information can take the form of quantifiable data, but it can also be a digital representation of pre-established certification schemes.

The further integration of blockchain technology in current biomass supply chains could contribute to keep on improving their performance, while satisfying consumer demands and contributing to the availability of data for sustainability assessments. Both operational and strategic information will more and more flow via the blockchain. Different business models will be implemented according to the need of the interested parties. In collaboration with certification and auditing entities, blockchain platforms have the potential to increase circularity and cascading of biomass. It could be used to improve the environmental and sustainability assessments and ultimately provide more accurate insights for policy making. This issue will be further detailed in the next CHAIN REACTION brief.

The potential impact of smart contracts is cross-border. Legislative measures, whether at the level of the Member-States or the EU, will have to follow these developments. These contracts have the potential to create increasing uncertainty in the area of jurisdiction



and choice of law. Can the current system of private law readily cope with these forms of 'self-executing' computer programmes and agreements? A notorious big legal issue is the 'right to be forgotten' in privacy law: how to implement this right if the information is stored in an immutable block on a blockchain?

Thus, existing EU instruments in the areas of cross-border enforcement of claims, procedural law and application of foreign law need to be carefully but urgently analysed against the light of the blockchain technology deployment by particular considering legal consequences of smart contracts.

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