# Smart Contract in the Supply Chain – A Bibliometric Analysis and Review

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**Abstract.** Over the past 10 years, blockchain technology has been increasingly applied in various industrial and scientific fields, including in the supply chain. Blockchain applications in the supply chain field that are starting to develop are decentralized applications without involving third parties, known as smart contract. Smart contract applications are computer protocols designed to facilitate, verify, and automatically enforce negotiations and agreements between multiple parties who may not know each other yet. However, how to form smart contract applications and how successful the application has not been widely discussed. This paper will review 39 literatures regarding smart contract in the supply chain that have been selected based on the criteria of the publisher, year of publication, number of citations, and keywords. The result of this literature review is the grouping of smart contract applications in various sectors in the supply chain, the methodology used, and the output from previous research. In addition, the analysis of keywords and future research on those articles was carried out.

## INTRODUCTION

The supply chain involves many processes from raw material procurement, production, delivery of finished products, to post-sales support (1). Of course, this process involves many entities and is a very complicated traceability process (2). This makes it difficult to trace information that occurs in the supply chain. For this reason, blockchain technology is an option that makes it possible to track and follow every product from raw materials to its entire life cycle (1). This blockchain traceability can also provide transparency in several processes such as during manufacturing, delivery, or payment (3).

Blockchain is a decentralized database that exists as a copy on a computer network (4). The characteristics of blockchain are traceability, data storage, privacy, and automation in supply chain processes (5). Blockchain cannot be manipulated so that all parties involved in the supply chain can gain high visibility through security in data-sharing mechanisms (6).

Blockchain can execute smart contract as transactions (6). Smart contract can be said to be the most promising technology for better traceability while maintaining privacy and transparency (1). Smart contract offer autonomous delivery scenarios by improving supply chain performance (7). Not limited to tracing functions, smart contract can also automate bidding procedures so that they are more reliable, transparent, and automatically trigger payments after the contract agreement has been fulfilled (1). Smart contract can perform tasks in real-time at low costs with a higher level of security (8). The use of smart contract on blockchain in the supply chain can improve accuracy, efficiency, speed, trust-building with resulting transparency, traceability, and security (6).

# RESEARCH METHODOLOGY

Article selection is done through several criteria fulfillment. The selection of whether the article can meet the criteria is done with the Harzing Publish or Perish application which was accessed from April until May 2022 and was carried out from Scopus, Web of Science, and Google Scholar. There are three defining criteria. The criteria are publisher, year of publication, and number of citations. Articles that are selected were published by IEEE Access and Elsevier. Then, the next criteria are articles published within the last 5 years or between 2018 and 2022. In addition, there is also a criterion number of citations where the selected articles have been cited more than or equal to 15 times.

The search was carried out on articles with two main keywords, namely smart contract and supply chain. The selected articles must have a relationship or application between the supply chain and blockchain, especially smart contract. Based on the criteria mentioned above, 39 eligible papers were obtained.

# SMART CONTRACT IN THE SUPPLY CHAIN

The concept of a smart contract was first introduced by Nick Szabo in 1994. A smart contract is defined as a computer-based transaction protocol that carries out the terms of the contract (8). A smart contract is a set of programs that can verify and execute themselves through blockchain thereby helping to minimize the need for third (7,8). In its operation and development, legal protection is needed like a legal agreement in general. Legal protection for technological protection measures and rights management information on smart contract is collectively referred to Digital Rights Management (DRM) (7).

Smart contract consist of values, functions, addresses, and states (9). Generally, the smart contract will store 5 data, namely timestamp, amount of currency sent, sender information, recipient information, and other required data (10). This technology runs an "if-then" condition in such a way that the user will pay a predetermined amount if the prerequisites in the contract have been met (7). The smart contract also allows parties to require that if one transaction occurs then another transaction will also occur (11).

A smart contract is a set of digital agreements represented in code and executed by a computer after a certain event (6). This makes it possible to initiate transactions between supply chain units that can coordinate and optimize the entire supply chain with the aim of minimizing transaction costs and resulting in transactions that are irreversible and resistant to disruption (7). Companies such as Maersk, Walmart, and Everledger have also explored the use of smart contract for tracking various shipments of goods such as meat, containers, and even diamonds (1).

Based on research conducted by Feiyang Qu, Hisham Haddad, and Hossain Shahriar in 2019 regarding the manufacture of smart contract in a business-to-consumer security-based supply chain system, a conclusion was found that compared to traditional systems in retail, smart contract have advantages in data traceability, auditing data, identity management, and uniformity of data verification.

## Sector, Methodology, and Output Analysis

In this subchapter, an analysis is carried out regarding the sectors discussed, the methodology used, and the outputs generated from the 39 selected articles. The existing supply chain sectors are divided into 15 sectors, namely agricultural supply chain, agriculture supply chain, agri-food supply chain, blood donation supply chain, business to consumer supply chain, developing country supply chain, distributed energy system, food supply chain, general supply chain, grain supply chain, humanitarian supply chain, medical supply chain, precast supply chain, review system, and soybean supply chain. Meanwhile, the methodology is divided into 3 methods, namely analysis, design and implementation, and systematic literature review. Sector determination and methodological grouping are in table 1.

**TABLE 1.** Sector determination and methodological grouping.

| (Citation) | Sector | Methodology | | |
|---|---|---|---|---|
| | | Analysis | Design model and implementation | Systematic literature review |
| (12) | General supply chain | | ✓ | |
| (13) | General supply chain | | ✓ | |
| (14) | Food | ✓ | | |
| (15) | General supply chain | ✓ | | |
| (16) | Developing country | ✓ | | |
| (17) | | | | ✓ |
| (18) | General supply chain | | | ✓ |
| (19) | General supply chain | ✓ | | |
| (20) | Agricultural supply chain | ✓ | | |
| (21) | Blood donation | | ✓ | |
| (22) | Agri-Food supply chain | | ✓ | |
| (23) | Medical supply chain | | ✓ | |
| (24) | Precast | ✓ | | |
| (25) | Grain supply chain | | ✓ | |
| (26) | Distributed energy system | ✓ | | |
| (27) | Soybean (Agricultural and food) supply chain | | ✓ | |
| (28) | General supply chain | | | ✓ |
| (29) | General supply chain | | | ✓ |
| (30) | General supply chain | | ✓ | |
| (31) | General supply chain | | ✓ | |
| (32) | General supply chain | | ✓ | |
| (33) | Food | | ✓ | |
| (34) | General supply chain | ✓ | | |
| (35) | Humanitarian supply chain | ✓ | | |
| (36) | Agriculture | | ✓ | |
| (37) | Review system | | ✓ | |
| (38) | General supply chain | | ✓ | |
| (2) | General supply chain | | ✓ | |
| (10) | Food | ✓ | | |
| (39) | General supply chain | ✓ | | |
| (5) | General supply chain | ✓ | | |
| (1) | General supply chain | | | |
| (40) | Business to consumer | ✓ | | |
| (41) | General supply chain | | | ✓ |

Based on selected articles related to smart contract in the supply chain, there are different output results. Each of these outputs is shown in table 2.

**TABLE 2.** Output / key findings.

| (Citation) | Output / Key Findings |
|---|---|
| (12) | A system that provides an efficient solution to automate and decentralize the supply chain management process |
| (13) | Preliminary study of smart contract to track the origin of a product and to maintain ownership of digital assets |
| (14) | A distributed ledger that can be accessed by all users |
| (15) | A combination of blockchain with distributed storage and blockchain model for the supply chain |
| (16) | An analysis of multiple case studies of blockchain in supply chains in developing countries |
| (17) | Investigation of blockchain developments trend |
| (18) | A bibliometric perspective of blockchain-related publications |
| (19) | An integrated Triple Retry framework for designing circular blockchain |
| (20) | Applications and techniques of blockchain technology that can used in the agricultural sector |
| (21) | Leverage traceability in BDSC |
| (22) | A solution for blockchain-based Agriculture and Food (Agri-Food) supply chain |
| (23) | A decentralized blockchain-based solution that can automate forward supply chain processes for the medical equipment especially COVID-19 and enable information exchange among all the stakeholders |
| (24) | A novel blockchain-based information management framework for precast supply chain |
| (25) | A new system architecture for guaranteeing safety process traceability and food quality |
| (26) | A distributed energy systems for more efficient power demand and trading management schemes |
| (27) | An approach for soybean traceability and tracking across the agricultural supply chain |
| (28) | A scheme for resolving the problem in the supply chain and automating the whole payment using smart contract |
| (29) | Deploy blockchain technology by identifying and understanding of the impact of blockchain technology that can offers a high level of transparency and has gained the attention from various sectors |
| (30) | A decentralized data management platform that can be used to execute bespoke distributed applications |
| (31) | A transformation of VMI supply chain operations by blockchain-based approach using smart contract |
| (32) | A smart construction objects enabled blockchain oracles framework |
| (33) | A system prototype of food safety traceability system based on EPCIS and blockchain |
| (34) | A model that enables the concept of circular economy that can eliminate the disadvantages of the current supply chain |
| (35) | The application of blockchain-based smart contract to humanitarian supply chains (HSCs) |
| (36) | A scheme of product traceability based on permisioned blockchain within a double-layer framework |
| (37) | A multi-blockchain gateway node that validates a new review from the supply chain system |

| | |
|---|---|
| (38) | A general model for blockchain enabled supply chain with the usage of three smart contract |
| (2) | A product traceability system based on blockchain technology |
| (10) | A demonstration of blockchain with IoT in the area of supply chain |
| (5) | An evaluation of the potential influence of blockchain on supply chain and a comparative analysis, future implications for similar attempts in different sectors, |
| (1) | A blockchain based solution involving items shipped via smart containers for efficient supply chain management |
| (40) | An investigation of the feasibility of Ethereum capabilities for an online supply chain system in B2C business model |
| (41) | Exploration of the current status, potential applications, and exploration about the future direction of blockchain technology in supply chain management |

## Keywords Analysis

Of the 39 selected articles, there are 97 different keywords. The keyword that appears most often is blockchain and smart contract each having a percentage of 13%. Then in the next sequence, smart contracts and supply chain management each have a percentage of 6%. Followed by supply chain at 5% and Ethereum at 4%. There is also traceability and IoT with 3% each. The rest 89 keywords occupy as much as 1% and 0% as shown in Table 3.

**TABLE 3.** Distribution of 97 keywords in the 39 selected journals

| Keywords | Amount | Percentage (n=215) |
|---|---|---|
| Blockchain | 28 | 13 |
| Smart contract | 27 | 13 |
| Smart contracts | 12 | 6 |
| Supply chain management | 12 | 6 |
| Supply chain | 11 | 5 |
| Ethereum | 8 | 4 |
| Traceability | 7 | 3 |
| IoT | 6 | 3 |
| Food Safety | 3 | 1 |
| Internet of Things | 3 | 1 |
| Block chain | 2 | 1 |
| Blockchains | 2 | 1 |
| Circular economy | 2 | 1 |
| Decentralized Application | 2 | 1 |
| Distributed ledger | 2 | 1 |
| Distributed ledger technology | 2 | 1 |
| Game theory | 2 | 1 |
| Hyperledger | 2 | 1 |
| Logistics | 2 | 1 |
| Smart-contract | 2 | 1 |
| Trust | 2 | 1 |
| Accountability | 1 | 0 |
| Agricultural supply chain | 1 | 0 |
| Agriculture supply chain | 1 | 0 |
| Agrifood supply chain | 1 | 0 |

| | | |
|---|---|---|
| AI planner | 1 | 0 |
| Artificial intelligence | 1 | 0 |
| Attribute-based Encryption | 1 | 0 |
| Blockchain applications | 1 | 0 |
| Blockchain technology | 1 | 0 |
| Blood donation supply chain | 1 | 0 |
| Business process re-engineering | 1 | 0 |
| Business-to-consumer business model | 1 | 0 |
| Byzantine failure tolerance | 1 | 0 |
| Circular blockchain | 1 | 0 |
| Circular supply chain management | 1 | 0 |
| Communication | 1 | 0 |
| Cross-chain interfacing | 1 | 0 |

The existing keywords are then divided into three major categories. The first is infrastructure and technology which includes blockchain and smart contract. Furthermore, there are categories of characteristics of smart contract in the supply chain such as traceability and accountability. The third category is the sector or implementation of smart contract in the supply chain sector, such as in the agricultural supply chain and humanitarian supply chain.

In the infrastructure and technology category, blockchain ranks first at 13%. Followed by smart contract with 13% and smart contract with a percentage of 6% closed with Ethereum as much as 4%. Furthermore, for the characteristic category of smart contract in the supply chain, the characteristic of smart contract in the supply chain that most often appears is traceability as much as 3%. Followed by several other characteristics, namely accountability, data integrity, and tamper proof. In addition, there are several other characteristics such as digital ledger, Hyperledger, security, shared ledger, and trust. Smart contract, in this case in the supply chain, are implemented in various sectors such as agricultural supply chains, food supply chains, grain supply chains, humanitarian supply chains, logistics, and smart supply chains.

Keywords are then clustered based on co-occurrence through the VOS Viewer application. Of the 97 existing keywords, 7 of them have a relationship as shown in Figure 1. The distance between keywords indicates the relationship between keywords while the same color indicates that the keywords are often used together.
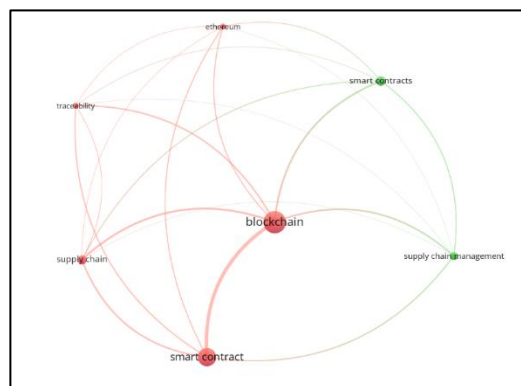


**FIGURE 1.** Co-occurrence of keywords using VOS Viewer

## Future Avenues Analysis

In this subchapter, an analysis of future research suggested by 28 of the 39 selected articles is carried out. The grouping is divided into three parts, namely sectors, future research topics, and methodologies. Suggested methods that can be used for further research are divided into 4 methods. These methods include analysis, case study, design and implementation, and systematic literature review. Analysis can be done on data, concepts, models, uses, or

processes. Case study can mean qualitative research through empirical tests carried out directly on existing conditions. Design and implementation can be interpreted as observation or analysis of the model that will be created and programming the model into an application on the blockchain. Systematic literature review is research in the form of a review of existing articles.

In the sector, the research is divided into 14 sectors in the supply chain. In alphabetical order, the sectors are agricultural systems supply chain, agriculture supply chain, agri-food (agricultural and food) supply chain, business to consumer supply chain, distributed energy system, food supply chain, general supply chain, government, healthcare supply chain, humanitarian supply chain, IoT and blockchain, medical supply chain, precast supply chain, and soybean supply chain. The grouping table equipped with future research topics looks like Table 4.

**TABLE 4.** Future Avenues Analysis

| (Citation) | Sectors | Topic | Methodology |
|---|---|---|---|
| (13) | General supply chain | Connecting IoT devices and the blockchain network | Design and implementation |
| (16) | Government | Blockchain's potential roles in enhancing government capacities and bridging the enforcement gap | Analysis |
| (17) | General supply chain | Blockchain and IoT implementations | Analysis |
| (18) | General supply chain | Study on blockchain in OSCM and its integration with other cutting-edge technologies, the role of blockchain in health care systems, etc | Analysis |
| (19) | Medical | Assuring the immediate need for personal protective equipment (PPI) by designing novel blockchain models | Design and implementation |
| (20) | Agricultural systems | Empirical test of agricultural system case study | Case study |
| (21) | Healthcare | Trace the provenance of COVID-19 | Design and implementation |
| | Agri-food | Refund and return mechanism in Agri-food products trading | Design and implementation |
| (23) | Medical | Dispose of medical waste by incentive system for the COVID-19 treatment hospitals | Design and implementation |
| (24) | Precast | Verifying the proposed model based on field data from practical construction industries | Analysis |
| (25) | IoT and blockchain | Ensure the credibility of information sources | Design and implementation |
| (26) | Distributed energy system | Improving this paper by its technical structure, applications, and governance | Design and implementation |
| (27) | Soybean (Agricultural and food) supply chain | Integrate within the proposed solution automated payments and proof of delivery | Design and implementation |
| (28) | General supply chain | Expansion from this paper in the form of a model and prototype of the arrangement | Design and implementation |

| | | | |
|---|---|---|---|
| (29) | General supply chain | Information hiding in parallel with information sharing within the supply chain | Design and implementation |
| (30) | General supply chain | Further performance testing and refinements of this study | Analysis |
| (31) | General supply chain | Fully automate the VMI process for all stakeholders using a decentralized applications | Design and implementation |
| (32) | General supply chain | Enrich the smart construction objects blockchain oracles framework | Design and implementation |
| (33) | Food | Optimizing the P2P Network Mode, the consensus algorithm of blockchain, and information clipping | Design and implementation |
| (34) | Agriculture | Introducing new agents for the monitoring of procedures for multi-agent system | Design and implementation |
| (35) | Humanitarian supply chains | Realizing the shift in trust-based theories in HSCs | Analysis |
| (36) | General supply chain | Double layer framework in blockchain based system | Design and implementation |
| (38) | General supply chain | Support a supply chain in a specific domain with this proof of concept | Analysis |
| (2) | General supply chain | Using IoT technology and using QR code to promote the process of improve consumer consumption experience , product source querying, and simplify the consumer operation process | Design and implementation |
| (5) | General supply chain | Improving supply chain performance by using the proposed blockchain based process | Analysis |
| (1) | General supply chain | Implementing a fully functional system with IoT enabled with Raspberry Pi board with connection to various sensors, and also developing front-end DApps | Design and implementation |
| (40) | Business to consumer | Developing a complete application on Ethereum to replace Truffle and Ganache and provide a custom interface so that users can interact with the Ethereum blockchain | Design and implementation |
| (41) | General supply chain | Blockchain technical issues such as scalability, throughput, security, and interoperability | Systematic literature review |

# CONCLUSION

In conclusion, a smart contract is a set of programs on a distributed database technology such as blockchain. The application of smart contract in the supply chain can increase transparency, traceability, and efficiency. In this study, 39 articles were reviewed based on the criteria of the publisher, year of publication, and number of citations. It was found that the sector of the article is divided into 15 sectors, namely agricultural supply chain, agriculture supply chain, agri-food supply chain, blood donation supply chain, business to consumer supply chain, developing country supply chain, distributed energy system, food supply chain, general supply chain, grain supply chain, humanitarian supply chain, medical supply chain, precast supply chain, review system, and soybean supply chain. Then, it is divided into 3 methodologies, namely analysis, design and implementation, and systematic literature review. The 39 articles produced different outputs as shown in this study.

In addition, an analysis of keywords is also carried out. The keywords that appear the most are blockchain and followed by smart contract. Then, there are smart contract and supply chain management with the same amount. Then the keywords that most often appear next are supply chain, Ethereum, traceability, and IoT. Furthermore, there is an analysis for future research that is listed in each article. Future research is divided into 14 sectors in the supply chain namely agricultural systems supply chain, agriculture supply chain, agri-food (agricultural and food) supply chain, business to consumer supply chain, distributed energy system, food supply chain, general supply chain, government, healthcare supply chain, humanitarian supply chain, IoT and blockchain, medical supply chain, precast supply chain, and soybean supply chain. Then grouped into 4 methods, namely analysis, case study, design and implementation, and systematic literature review. Topics for future research have been listed in this study.

In future research, we plan to make a model and implementation of smart contract in the insurance supply chain sector. It is hoped that this research can help future research that discusses the link or implementation between smart contract and the supply chain.

# ACKNOWLEDGMENTS

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