**CHAPTER-2**

**INTRODUCTION**

IN recent years, the problems of agri-food safety and farmer income have received widespread attentions [1][4]. The issues of agri-food safety may occur in each part of agri-food supply chains (ASCs), while inefficient management strategies of ASCs would lead to low profits. However, many factors may constrain the normal work of ASCs. First, due to the complex structure of ASCs, it is hard to record the full circulation information of agri-food products while ensuring that the information will never be tampered with. Second, the shift of consumer preferences has become the main barrier of precisely determining the production and storage of agri-food products with the consideration of profit maximization. Such uncertainties and dynamics undoubtedly increase the toughness of designing an efficient ASC framework. To address these problems, the effective traceability and management for agri-food products in ASCs have become urgently necessary [5], [6]. On one hand, to guarantee the agri-food safety, the information of agri-food products in ASCs including production, processing, storage, distribution, and retail should be collected and recorded when establishing a mechanism of product traceability [7]. However, most of the traditional traceability solutions of ASCs rely on a centralized system maintained by a trusted third party, which may suffer from the potential single-node failure and security threats such as data tampering and information leakage [8]. Blockchain, a distributed, append-only, and tamper-proof ledger, offers an effective architecture for reliable transactions on the Bitcoin network [9] without the control of a centralized third party. Each information recorded in a blockchain should be verified by the majority of participants to reach a global consensus, which ensures the information source with auditability and transparency. Moreover, there is no need for a blockchain-based traceability solution to connect to a remote cloud data center because it only requires the stable connection among adjacent participants. Therefore, the blockchain technology can be used to realize a reliable product traceability in supply chains, which has recently become a new research direction and attracted many research interests. For example, Tian [10] proposed a traceability system for ASCs with the radio frequency identification (RFID) and blockchain technologies, where RFID-based devices and blockchains are used for collecting and storing data, respectively. Furthermore, the author [11] designed another traceability system for ASCs based on the Hazard Analysis and Critical Control Points (HACCP), blockchain and Internet-of-Things (IoT) technologies. Toyoda et al. [12] proposed a blockchain-based product ownership management system (POMS), which can be used to prevent counterfeit products in supply chains. Caro et al. [13] developed the Agri Block IoT, a blockchain-based traceability solution, which can acquire the agri-food data of production and consumption from IoT devices along ASCs. Mao et al. [14] designed a blockchain-based credit evaluation system to optimize the supervision and management of food supply chains, which collected the credit via smart contracts and made analysis by using the long short-term memory (LSTM). Lin et al. [15] proposed an information and communications technology (ICT) based system by integrating the blockchain technology. Tse et al. [16] discussed the application of the blockchain technology to the food supply chain and made comparisons with traditional traceability systems. Abeyratne and Monfared [17] proposed that the application of blockchains can help raise trust levels of supply chains by using transparent and traceable transactions.

**2.1 LITERATURE SURVEY**

# 1. Title: Blockchain and Its Impacts on Agri-Food Supply Chain Network Management

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**ABSTRACT:** Blockchain is an emerging meta-technology and considered a new institutional technology with the potential to change the governance of vertically integrated food supply chains. This paper investigates the effects on coordination mechanisms in vertically cooperating agri-food networks that result from the implementation of different blockchain technology platform types (BCTPT). The research is based on an extensive literature overview and exploratory use cases of BCTPT implementations in the agri-food industry which are presented to illustrate the applicability of the findings. Our analysis shows that BCTPT predominantly differentiate through the coordination mechanisms exerting of power, information sharing, decision-making, and collective learning benefits. We also reveal that blockchain use cases with high success rates typically operate in a vertical ecosystem where a focal firm assumes the responsibility for coordinating the activities in the supply chain network. These use cases are typically operationalized in tracking and tracing applications as well as in provenance-based information provision, which either operate in vertically coordinated private blockchain or consortium-type blockchain platforms. We conclude that the choice of a specific BCTPT with its respective coordination mechanisms is a key determinant of the economic success of the intended use case, the efficient management of the supply chain network, and eventually for the chosen digital business model. This paper will close a research gap, as the potential impacts of different blockchain technology platform types on digital agri-food business models and its supply chain management have scarcely been researched.

# 2.Title: Blockchain-Based Agri-Food Supply Chain: A Complete Solution

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**ABSTRACT:** Supply chains are evolving into automated and highly complex networks and are becoming an important source of potential benefits in the modern world. At the same time, consumers are now more interested in food product quality. However, it is challenging to track the provenance of data and maintain its traceability throughout the supply chain network. The traditional supply chains are centralized and they depend on a third party for trading. These centralized systems lack transparency, accountability and auditability. In our proposed solution, we have presented a complete solution for blockchain-based Agriculture and Food (Agri-Food) supply chain. It leverages the key features of blockchain and smart contracts, deployed over ethereum blockchain network. Although blockchain provides immutability of data and records in the network, it still fails to solve some major problems in supply chain management like credibility of the involved entities, accountability of the trading process and traceability of the products. Therefore, there is a need of a reliable system that ensures traceability, trust and delivery mechanism in Agri-Food supply chain. In the proposed system, all transactions are written to blockchain which ultimately uploads the data to Interplanetary File Storage System (IPFS). The storage system returns a hash of the data which is stored on blockchain and ensures efficient, secure and reliable solution. Our system provides smart contracts along with their algorithms to show interaction of entities in the system. Furthermore, simulations and evaluation of smart contracts along with the security and vulnerability analyses are also presented in this work.

# 3.Title: Blockchain-based agri-food supply chain management: case study in China

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**ABSTRACT:** The fundamental purpose of agri-food supply chain management is to restrict opportunism caused by information asymmetry. Traditional Chinese agri-food supply chain management introduces a contract mechanism and a trust mechanism to manage the uncertainty of the agri-food quasi-organization. However, it is almost impossible to improve the efficiency of transactions and maintain agri-food supply chain stability in the case of asymmetric information. Nowadays, blockchain, Internet of Things technology and big data drive the agri-food supply chain into a vast smart network which would break the information constraints. This paper analyzes the coupling between blockchain-based digital system and the agri-food supply chain. In addition, this paper presents two cases from China, indicating that the proposed blockchain-based system can achieve disruptive transformation in agri-food supply chain management.

# 4.Title: Exploring the impact of blockchain on the performance of agri-food supply chains

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# ABSTRACT: The implementation of the blockchain technology in the agri-food supply chains is in its introductory phase. Lead companies, often retailers, introduce this technology for specific objectives, such as assuring traceability or improving sales and reputation. At the same time, the technology could impact much more broadly the performances of food chains. Little is known about this impact as the evidence provided in the literature is scarce and mostly focused on specific indicators. This paper addresses this gap assessing the impact of the blockchain technology on food supply chains from an explorative perspective. An integrated conceptual framework is proposed which includes a broad set of performance dimensions discussed in the literature: efficiency, flexibility, responsiveness, food quality, and transparency of supply chains. These dimensions are assessed using a case study, consisting of three supply chains where a large European retailer has promoted the blockchain adoption. Data was collected through semi-structured interviews with key managers at different stages of the three supply chains and were systematically analysed through a thematic analysis. Results reveal that blockchain technology impacts positively on the profit and/or return on investment of supply chains, it leads to an increase of extrinsic food quality attributes and it fosters a better information management along the food chains due to an improved information accessibility, availability and sharing. The current analysis also suggests an improved management of behavioural uncertainty among the agents of the supply chains and an increase of firm's knowledge as well as supply chain management competencies. While the study remains of explorative nature, it offers a basis for the selection of theoretical approaches and the formulation of new hypotheses for future blockchain studies

# 5.Title: Blockchain-based traceability in Agri-Food supply chain management: A practical implementation

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**ABSTRACT:** The recent, exponential rise in adoption of the most disparate Internet of Things (IoT) devices and technologies has reached also Agriculture and Food (Agri-Food) supply chains, drumming up substantial research and innovation interest towards developing reliable, auditable and transparent traceability systems. Current IoT-based traceability and provenance systems for Agri-Food supply chains are built on top of centralized infrastructures and this leaves room for unsolved issues and major concerns, including data integrity, tampering and single points of failure. Blockchains, the distributed ledger technology underpinning cryptocurrencies such as Bitcoin, represent a new and innovative technological approach to realizing decentralized trustless systems. Indeed, the inherent properties of this digital technology provide fault-tolerance, immutability, transparency and full traceability of the stored transaction records, as well as coherent digital representations of physical assets and autonomous transaction executions. This paper presents AgriBlockIoT, a fully decentralized, blockchain-based traceability solution for Agri-Food supply chain management, able to seamless integrate IoT devices producing and consuming digital data along the chain. To effectively assess AgriBlockIoT, first, we defined a classical use-case within the given vertical domain, namely from-farm-to-fork. Then, we developed and deployed such use-case, achieving traceability using two different blockchain implementations, namely Ethereum and Hyperledger Sawtooth. Finally, we evaluated and compared the performance of both the deployments, in terms of latency, CPU, and network usage, also highlighting their main pros and cons.