커피 공급망의 전통적 순환경제 vs 통합적 블록체인 기술 비교 연구

초느에진랏 [1], 이구구 치세케디 에티엔 [1], 무함마드 필다우스 [2], 이경현 [3]
[1]부경대학교 정보보호학과
[3] 부경대학교 인공지능융합학과
[3]부경대학교 컴퓨터인공지능공학부 교수
chocho1612@pukyong.ac.kr, etienneiget5@gmail.com, mfirdaus@pukyong.ac.kr, khrhee@pknu.ac.kr

Traditional Circular Economy vs Integrated Blockchain Technology in the Coffee Supply Chain: A Comparative Study

Cho Nwe Zin Latt[1], Igugu Tshisekedi Etienne[1], Muhammad Firdaus[2], Kyung-hyune Rhee[3]
[1]Dept. of Information Security, Pukyong National University
[2]Dept. of Artificial Intelligence Convergence, Pukyong National University
[3]Division of Computer and AI Engineering, Pukyong National University

Abstract

The circular economy approach in the coffee supply chain promotes a more sustainable, environmentally friendly, and socially responsible coffee industry. It aims to reduce the environmental impact of coffee production and consumption while ensuring the long-term viability of coffee farming communities and ecosystems. However, there are many challenges in the traditional circular economy coffee supply chain. Hence, this paper undertakes a comparative analysis between the traditional circular economy coffee supply chain and its integration with blockchain. As a result, we display the benefits of incorporating blockchain technology into the conventional circular economy framework of the coffee supply chain. Additionally, this integration promises to overcome the challenges in the traditional circular economy coffee supply chain.

1. Introduction

The coffee supply chain is a critical aspect of the coffee business, and its management plays a significant role in ensuring the success and sustainability of the industry. Several factors influence the performance and sustainability of the coffee supply chain. These factors include economic, social, and environmental aspects and the flow of materials, information, and finances. Implementing strategies based on supply chain sustainability indicators can help overcome the challenges faced in the coffee supply chain, such as blocked chains and non-optimal flow. Additionally, green supply chain management practices, such as green cultivation, processing, and distribution, can address common problems in coffee processing, such as waste management and ecological impact. Top management sensitivity and institutional forces can stimulate supply chain coordination towards green, leading to improved financial and market performance. Understanding and effectively managing the coffee supply chain is crucial for promoting sustainable coffee development and ensuring the industry's competitiveness. Blockchain technology has been adopted in the traditional circular economy of the coffee supply chain to improve transparency, traceability, and efficiency in asset tracking. Implementing blockchain in the coffee retailer network can bring transparency, sustainability, and efficiency in asset tracking [1]. The blockchain facilitates a more efficient circular economy system, especially in closed-loop supply chain (CLSC) systems. The adoption of blockchain technology enables better return processes by improving the operations in CLSC and services in reverse omnichannel. The proposed blockchain technology model can identify and reduce functional growth risk factors in the green supply chain economy. Blockchain technology can improve corporate governance, environmental impact, and social good by increasing supply chain transparency, traceability, and accountability [2]. The implementation of blockchain

technology for the coffee supply chain was explored through a proof of concept on Hyperledger Fabric, which allowed for tracing product origin using a distributed ledger.

This paper examines how the traditional circular economy (CE) coffee supply chain can be improved by integrating blockchain technology, as well as how to deal with its existing problems [3]. By integrating blockchain technology into the coffee supply chain, our key purpose is to increase transparency, traceability, and accountability throughout the whole supply chain process.

The structure of this paper is as follows: Section 2 explains the traditional circular economy of the coffee supply chain. Section 3 discusses the comparison of coffee supply chains and the benefits of integrating blockchain technology. Finally, Section 4 concludes this paper.

2. Traditional circular economy in the coffee supply chain

The concept of "traditional circular economy" in the framework of the coffee supply chain in Figure 1 refers to the traditional linear model of coffee production, distribution, and consumption, where resources are extracted, processed, used, and disposed of with little regard for sustainability or environmental impact [3]. With little attention paid to waste management, environmental effects, emission reduction, or resource optimization, coffee beans are cultivated, harvested, processed, and transported to various supply chain steps, including roasting, packaging, distribution, and consumption. It can be challenging to trace coffee beans' origin, quality, and sustainability practices and to ensure accountability for their effects on social and environmental issues since the traditional circular economy in the coffee supply chain requires increased transparency and traceability. However, with the development of innovative technologies like blockchain, there is a chance of transforming the existing circular economy in the coffee supply chain through enhancing transparency, traceability, and accountability and encouraging environmentally friendly practices throughout the supply chain process [4].

By preserving products and supplies in use and regenerating the environment, the traditional circular economy in the coffee supply chain works to reduce waste and pollution. The coffee industry is aware of how critical it is to move toward a circular economy, and there are many ways to do it. Reusing coffee pulp, organic pruning waste, and wastewater from coffee processing is one technique to increase the productivity of coffee farms and the livelihoods of farmers. Utilizing leftover coffee grounds for diverse products including biofuels, bioplastics, and cosmetics is another option. The entire coffee supply chain must be considered to achieve a circular economy, and solutions that emphasize regeneration rather than extraction must be put into practice. A major challenge will be the shift to a circular economy [5]. The food sector is ready to follow the coffee business in closing the production loop, which will reduce resource costs and cause damage to the environment.

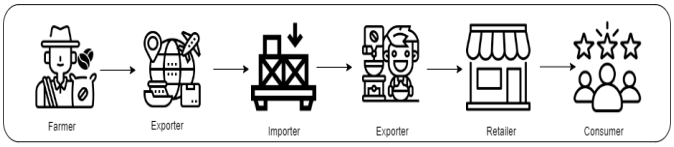

Figure 1. Coffee Supply Chain

2.1 The challenges of traditional circular economy in the coffee supply chain

The challenges in the coffee supply chain can be addressed by implementing an integrated plan involving sustainable infrastructural facilities, attempts to end farmer poverty, recycling damaged products, and supplier monitoring utilizing environmental standards [6].

A number of barriers hinders the traditional circular economy in the coffee supply chain, including:

- *Climate change:* Decades of the "take-make-waste" mentality have created a climate problem, and due to global warming, the coffee industry is at risk of reduced efficiency. The quantity of area that can be used to grow coffee is currently decreasing due to rising temperatures, and coffee leaf rust outbreaks are becoming more common due to unpredictable rainfall patterns.
- *Complex supply chain:* It is difficult to apply circular economy methods since the coffee supply chain is complicated and has many intermediaries. Circular economy production systems face significant obstacles because of the supply chain for coffee capsule manufacture that uses reverse logistics.
- *Resistance to change:* The transition to a circular economy requires a considerable change in perspective and behavior, and certain participants in the coffee supply chain may be resistant to change. For the coffee business to save money and protect the environment, it must transition to a circular economy.
- *Lack of infrastructure:* Implementing circular economy principles in the coffee supply chain can require large infrastructure investments, such as in waste management and recycling systems.
- *Limited consumer awareness:* There may not be enough demand for circular economy products and consumers may need to be made aware of the advantages of a circular economy in the coffee supply chain.

In the final analysis, there are several challenges to the traditional circular economy in the coffee supply chain, such as climate change, an elaborate supply chain, opposition to change, a lack of infrastructure, and low consumer awareness. All participants in the coffee supply chain will need to work together and be innovative to overcome these challenges [7].

3. Comparison of Traditional vs Blockchain-Integrated CE Coffee Supply Chain

We compared the features of the traditional circular economy (CE) coffee supply chain with the CE coffee supply chain integrated with blockchain in Table 1. The features compared included traceability, transparency, security, efficiency, cost, complexity, and regulation [8]. As a result, following are some advantages of integrating blockchain technology into the coffee supply chain:

- *Transparency:* Blockchain technology can increase transparency in the coffee supply chain so that growers can see where their beans are used, and customers can learn more about the origins of their coffee. This transparency can ensure that farmers receive just crop payments and uphold sustainable farming methods.
- *Traceability:* By enabling end-to-end traceability throughout the coffee supply chain, blockchain technology enables customers to follow their coffee beans from the farm to the cup. This traceability guarantees that coffee beans are sourced ethically and that social and environmental criteria are maintained.
- *Reduced risks:* Blockchain technology can lower supply chain transparency, forgery, and fraud risks. The performance of businesses in the coffee supply chain may increase due to this risk reduction.
- *Increased efficiency:* By reducing intermediaries and the time and money they add to the supply chain, blockchain. technology can improve the efficiency of the coffee industry. By increasing efficiency, the coffee supply chain can become more circular, and waste can be reduced.
- *Improved sustainability:* By adding a digital layer to the physical commodity flow and enabling the valorization of waste and byproducts, blockchain technology can enhance the ecological embeddedness of the coffee supply chain. The coffee supply chain's increased sustainability could reduce its adverse environmental impacts.

Table 1: Comparison of CE Coffee Supply Chain

Feature	Traditional Circular Economy Coffee Supply Chain	Blockchain-Integrated Circular Economy Coffee Supply Chain
Traceability	Limited traceability, as information, is often siloed and not shared between different actors in the supply chain.	A higher traceability standard since the blockchain can be used to track coffee bean transportation from the farm to the cup. This can support sustainable production and trade of coffee.
Transparency	Limited transparency, as information about the coffee supply chain, is often not accessible to consumers.	Consumers may have better access to information about the coffee supply chain with increased transparency due to technologies like blockchain. This may foster accountability and trust.
Security	Vulnerable to fraud and tampering, as information is often stored in centralized databases.	Blockchain is a decentralized technology that makes transactions more secure since it resists fraud and tampering.
Efficiency	It can be inefficient, as the coffee supply chain is often fragmented, and different actors need more coordination.	It is more efficient since blockchain may improve the coffee supply chain and reduce the need for mediators.
Cost	It can be expensive, as implementing circular economy practices can be expensive, especially for small coffee farmers.	Although the cost of deploying blockchain technology can be considerable, the cost is anticipated to decrease as the technology develops.
Complexity	It can be complex, as circular economy practices can be challenging to implement and require coordination between different actors.	In addition to being a complicated technology, blockchain can be hard to understand and use.
Regulation	The regulatory environment for circular economy practices is still evolving.	Additionally, still developing is the regulatory framework surrounding blockchain technology.

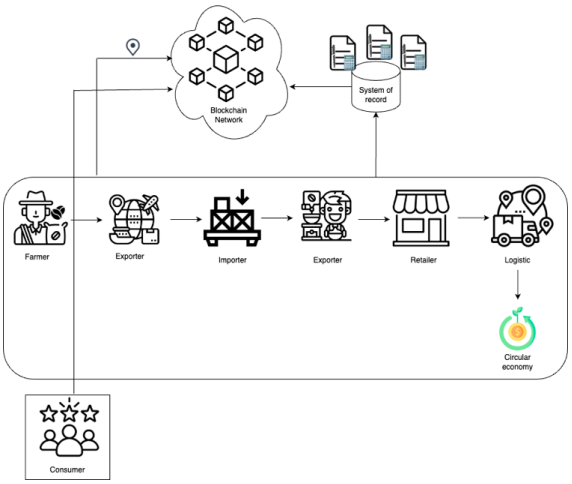

Figure 2. Integration Blockchain in the coffee supply chain

As discussed in section 2, the traditional circular economy of the coffee supply chain faces several challenges, such as

climate change, a complex supply chain, disagreement with change, a lack of infrastructure, and a lack of consumer awareness. Blockchain technology can help address some of these issues by bringing transparency, traceability, and efficiency to the coffee supply chain, and by enhancing the ecological embeddedness of the coffee supply chain through incorporating a digital layer into the physical commodity flow and enabling the valorization of waste and byproducts.

In Figure 2, blockchain technology can be used to track coffee beans from planting to sale, creating a secure ledger with information about the origin of the beans, date and time stamps for transactions, number of beans exchanged, cost of each transaction, and identities of parties involved. Blockchain technology provides a secure and incorruptible platform for stakeholders in the coffee supply chain industry, allowing them to record all relevant information related to the processing of coffee beans. This data is tracked throughout the entire supply chain and provides transparency to end consumers, ensuring their safety. Blockchain technology can be used to increase the traceability, transparency, and security of the coffee supply chain. This data can be used to check for fraudulent or mislabeled coffee beans, as well as monitor how producing coffee affects the environment. Ultimately, this data can help foster consumer trust and align with the sustainability goals of the circular economy [9]. To ensure a smooth transition from the packaging unit of coffee beans to the consumer unit, we should explore technologies like RFID tags, QR codes, and smart contracts. We should also discuss using digital certificates, unique identifiers, and blockchain verification at each stage, as well as the selective application of blockchain and the cost-benefit analysis of data value. Scalability concerns should be addressed through alternative technologies, layer-two solutions, or off-chain approaches.

4. Conclusion

The traditional circular economy coffee supply chain intends to reduce waste and pollution in the coffee industry by reusing and recycling resources. This approach involves repurposing coffee packaging, upcycling bags, recycling coffee grounds, and providing sustainable agricultural training to coffee farmers. Integrating blockchain technology into this framework enhances traceability and transparency, enabling the monitoring of coffee beans' journey from farm to cup. This integration can improve the sustainability of coffee production and trade.

To maximize scalability and cost-effectiveness when implementing blockchain in the coffee supply chain, it is crucial to selectively apply blockchain to critical areas, utilize sharding or sidechains to enhance transaction processing capacity, and conduct a comprehensive cost-benefit analysis. Challenges such as implementation costs, technological complexity, and regulatory uncertainties must also be considered. Lastly, our future study will integrate blockchain technology into a circular economy coffee supply chain.

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