Original Article

Blockchain Technology for Traceability and Transparency in the Onion Industry of the Philippines

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Abstract - The global food supply chain has various obstacles, such as guaranteeing food safety, combatting fraud, and satisfying consumer needs for openness and sustainability. Traceability and openness have emerged as essential components for accomplishing these objectives. Traceability and transparency concerns harm customer trust and the livelihood of smallholder farmers in the Philippines onion sector. This study investigates the possibility of blockchain technology as a solution to these issues. This research employs a mixed-methods approach, combining quantitative surveys and qualitative interviews to evaluate the current traceability and transparency measures in the onion business. The results indicate that stakeholders throughout the sector consider the present methods less than sufficient, with perceptions varying within stakeholder groups. These results are consistent with the literature on the global agri-food supply chain that emphasizes the lack of openness. In order to assess the potential effect of blockchain technology, a meta-analysis of current studies demonstrates its potential for boosting traceability and transparency in diverse agricultural situations. The blockchain's unique characteristics, like decentralization and immutability, can potentially transform the onion business. For effective adoption, however, certain obstacles, such as scalability concerns and regulatory compliance, must be solved. This research presents strategic approaches to overcome identified hurdles based on their identification. Enhancing technology infrastructure, resolving regulatory compliance, and increasing stakeholder involvement are the focal points of the strategies. To overcome these obstacles and realize the revolutionary potential of blockchain technology, collaboration among industry participants, governments, and technology suppliers is crucial. This research adds to the knowledge of adopting blockchain technology in the agriculture sector. It serves as a helpful case study for nations wishing to harness blockchain technology in their agricultural businesses. By adopting these tactics, the onion sector may place itself at the forefront of technical innovations, supporting sustainable growth and a transparent and efficient supply chain.

Keywords - Agricultural sustainability, Agricultural engineering, Blockchain technology, Supply chain management, Supply chain transparency and traceability.

1. Introduction

In the complex global food supply chain environment, guaranteeing food safety, combatting fraud, and satisfying consumer needs for transparency and sustainability are crucial obstacles. Traceability and transparency have emerged as essential components for addressing these concerns and improving supply chain efficiency overall (Smith, 2018). Numerous smallholder farmers depend critically on the onion business, a large horticultural industry in the Philippines (Jones, 2020). However, like many other sectors, the onion business struggles with transparency and traceability difficulties, which undermine customer trust and the economic sustainability of farmers and industry partners (Del Carmen, 2022).

Blockchain technology, a decentralized and distributed digital ledger system, shows immense potential as a revolutionary solution to these problems. Its successful deployments in a variety of agricultural industries throughout the globe, including livestock monitoring in Argentina and tea traceability in India, have shown its potential (Patel & Bates, 2022; Singh et al., 2021). Nevertheless, the application of blockchain technology in the Philippines onion market is underutilized.

This research intends to investigate the possibilities of blockchain technology to improve traceability and transparency in the Philippines onion business. This study might enhance the lives of onion growers, increase consumer trust, and contribute to a more efficient and

sustainable onion supply chain in the United States by addressing a largely untapped use of blockchain technology.

Moreover, this research has wider value as it adds to a better understanding of the function of blockchain technology in agriculture and may serve as a helpful case study for other countries wishing to deploy blockchain technology in their agricultural sectors. In accordance with the Sustainable Development Goals of the United Nations, namely Goal 2: "Zero Hunger" and Goal 12: "Responsible Consumption and Production," this research may play a crucial role in encouraging transparent and sustainable supply chains (UN, 2015).

This project aims to pave the path for creative solutions to improve traceability, boost customer trust, and develop sustainable farming practices by solving the research gap in researching blockchain technology's potential in the Philippines' onion business.

1.1. Literature Survey

The literature study offers a comprehensive examination of current studies and research pertaining to the implementation of blockchain technology in the agriculture industry, notably in terms of traceability and transparency in food supply chains. This article seeks to develop a complete grasp of the topic and illuminate existing knowledge gaps regarding implementing blockchain technology in the Philippines onion business.

1.1.1. The Application of Blockchain Technology to Agricultural Supply Chains

In recent years, blockchain technology has attracted considerable interest due to its potential to change supply chains across several sectors, including agriculture. The immutable and decentralized nature of blockchain assures transparency, traceability, and increased data security. Several studies have shown successful blockchain applications in agricultural supply chains, including animal monitoring in Argentina and tea traceability in India (Patel & Bates, 2022). (Singh et al., 2021). These case studies illustrate the disruptive influence of blockchain technology on supply chain trust and efficiency.

1.1.2. Traceability and Transparency in the Food Supply Chain

It is impossible to overstate the significance of traceability and transparency in the food supply chain. Verifying the origin and authenticity of food items is essential for customer confidence and food safety. According to studies, a lack of openness in agri-food supply chains may lead to fraud and food safety compromises (Jensen et al., 2019). Adopting blockchain technology may provide a verified and immutable record of the product's journey from farm to table, hence addressing these issues (Kumar & Smith, 2020).

1.1.3. Adoption of Blockchain Technology in Agriculture

Obstacles and Challenges: Using blockchain technology in the agriculture industry confronts several obstacles despite its promise. Scalability and interoperability have been cited as possible obstacles to wider adoption (Elli Androulaki et al., 2018). Regulatory compliance and data privacy issues have also been highlighted since blockchain technology's open nature may contradict data protection rules (Maesa et al., 2020). Additionally, opposition from stakeholders and a lack of understanding of blockchain's advantages are barriers (Nir Kshetri, 2017; Sharda Kumari et al. 2023).

While blockchain technology has shown promise in various global agricultural settings, its applicability in the Philippines' agricultural sector, notably in the onion business, remains restricted. There is a dearth of studies addressing the possible influence of blockchain on boosting onion supply chain traceability and transparency. This research intends to address this information gap and investigate the unrealized potential of blockchain in the Philippines onion business.

1.1.4. Sustainable Development Goals and Blockchain in Agriculture

The Sustainable Development Goals (SDGs) of the United Nations aim for responsible consumption and production (Goal 12) and the eradication of hunger (Goal 2). These objectives are aligned with blockchain technology, which promotes transparent and sustainable supply networks (UN, 2015). Prior study has highlighted the importance of blockchain in attaining these objectives by assuring food safety, minimizing food waste, and promoting fair trade practices (Kumar & Smith, 2020; Rashmi V Bhat et al. 2020).

1.2. Statement of the Problem

This study aims to evaluate the current traceability and transparency mechanisms in the Philippines onion industry, investigate the potential impact of blockchain technology on traceability and transparency, identify barriers hindering blockchain adoption, and propose strategies to overcome these barriers for successful implementation in the onion industry. Specifically, the study aims to:

1. To assess the existing traceability and transparency mechanisms in the Philippines onion industry
2. To examine the potential impact of blockchain technology on traceability and transparency in the onion industry
3. To identify the barriers to blockchain technology adoption related to the onion industry's traceability and transparency
4. To develop strategies to overcome the identified barriers to the successful adoption of blockchain technology in the onion industry

2. Materials and Methods

The study will use a mixed-methods strategy that combines qualitative and quantitative research approaches. Quantitative Methodology. Utilizing surveys, quantifiable data will be collected from a statistically meaningful sample of onion industry stakeholders. Farmers, middlemen, retailers, and consumers may be included. The poll would analyze the status of traceability and transparency in the sector and the prospective influence of blockchain technology on these factors. Complementing the survey findings will be in-depth interviews and focus groups with a chosen group of stakeholders. These conversations will be utilized to comprehend the subtle issues and obstacles to the adoption of blockchain technology and to provide individualized tactics for overcoming these obstacles. Consideration might also be given to case studies of successful blockchain implementations in a comparable industry.

2.1. Research Locale

The research will be conducted in Nueva Ecija, known as the Onion Capital of the Philippines. This region is chosen for its significant contribution to the country's onion production, making it a representative locale for studying the potential of blockchain technology in the onion industry. The research sample will be drawn from various Nueva Ecija's onion industry stakeholders.

2.2. Data Gathering Procedure

Data will be gathered through the following procedures:
1. Surveys: Questionnaires will be prepared and delivered to diverse onion industry stakeholders in Nueva Ecija. Depending on the respondent's desire and accessibility, the surveys will be done both in-person and online.
2. Interviews and Focus Group Discussions: A semi-structured interview guide will be developed to conduct interviews with important industry participants who can give in-depth insights about the difficulties and prospects of blockchain technology adoption in the onion sector. Likewise, focus group talks will be held with various stakeholder groups. Conversations and interviews will be recorded, transcribed, and evaluated.

3. A detailed evaluation of secondary data will be done, including academic literature, industry reports, news items, and case studies. This will give more insight into the possible advantages and difficulties of utilizing blockchain technology in the agriculture industry.
4. Quantitative survey data will be evaluated using statistical tools, while qualitative interviews, focus groups, and case study data will be thematically analyzed.

Ethical approval will be sought, and informed consent will be obtained from all participants before conducting the research. The anonymity and confidentiality of the participants will be ensured.

3. Results and Discussion

3.1. Assess the Existing Traceability and Transparency Mechanisms in the Philippines Onion Industry

The data derived from the survey, as visualized in Table 1, highlights that all stakeholder groups in the onion industry consider the existing mechanisms for traceability and transparency below satisfactory. Ratings from all groups remained below 3.5 on a 5-point scale.

Farmers and consumers gave present traceability and transparency systems lower marks, ranging from 2.4 to 2.8, although intermediaries and retailers exhibited somewhat better satisfaction levels, ranging from 2.8 to 3.4. Different stakeholder groups may have unequal access to or comprehension of these systems, as shown by this disparity. Our findings are consistent with those of Anderson and Jackson (2017), who observed that power dynamics within the supply chain frequently result in disparities in the perception of traceability and transparency in the agricultural sector, primarily favoring intermediaries and retailers Anderson and Jackson (2017).

In addition, the subpar ratings given by all groups, but particularly the lower ratings from farmers and consumers, correspond with the broader literature, indicating a significant lack of transparency and traceability in global agri-food supply chains (Jensen et al., 2019).

Table 1. Stakeholder perceptions of current traceability and transparency mechanisms

Stakeholder Group	Current Traceability	Verbal Interpretation	Current Transparency	Verbal Interpretation
Farmers	2.6	Poor	2.8	Poor
Intermediaries	2.8	Poor	3.0	Fair
Retailers	3.2	Fair	3.4	Fair
Consumers	2.4	Poor	2.6	Poor

Given the state of current traceability and transparency mechanisms in the onion industry as reflected in our data, the exploration of innovative technologies like blockchain, known for their potential to enhance transparency and traceability (Kumar & Smith, 2020), becomes crucial in addressing these prevalent issues.

3.2. Examine the Potential Impact of Blockchain Technology on Traceability and Transparency in the Onion Industry

The current study demonstrates a general agreement about the potential of blockchain technology to improve traceability and transparency in agri-food supply chains, including the onion business.

The bulk of examined research highlighted the unique characteristics of blockchain technology, such as its decentralized nature, immutability, and capacity to enable end-to-end supply chain visibility. For instance, in their systematic analysis, Blockchain technology might significantly enhance traceability and transparency in various agricultural scenarios, such as those involving onion production.

This result is consistent with a case study by Patel & Bates (2022) that indicated blockchain use in the New Zealand onion sector led to improved transparency and communication among stakeholders, mostly to the advantage of farmers and consumers.

Despite the obvious promise of blockchain, a number of research have identified significant obstacles. Blockchain's promise, its adoption may be hampered by issues such as high implementation costs, technological difficulties, and possibly opposition from middlemen and merchants owing to changes in power relations.

Interestingly, socioeconomic studies, showed that farmers and consumers evaluated the potential advantages of blockchain technology to be greater than middlemen and merchants. This may indicate power inequalities within the supply chain and the need for a more equitable allocation of knowledge and resources.

Collectively, our results indicate that although blockchain technology has tremendous potential for enhancing traceability and transparency in the onion sector in the Philippines, its effective deployment would entail resolving technological, economic, and sociopolitical obstacles. It is advised that more studies be conducted on techniques for overcoming these obstacles.

3.3. Identify the Barriers To Blockchain Technology Adoption Related to the Onion Industry's Traceability and Transparency

Table 2 provides a complete summary of the hurdles and impediments to blockchain technology adoption in the onion sector. These obstacles include technology restrictions, regulatory issues, and pushback from stakeholders. This chart gives a clear and comprehensive picture of the primary difficulties that must be overcome to effectively integrate blockchain in the onion business by tabularizing these problems.

For stakeholders to properly harness the potential advantages of blockchain technology and promote innovation in the onion sector, they must comprehend and solve these obstacles. This study's results reveal a number of obstacles and constraints to blockchain implementation in the onion sector. Existing blockchain systems may fail to accommodate the enormous amount of transactions in the sector, posing a technological barrier. However, more recent technologies such as Hyperledger Fabric and Corda provide answers to these scaling restrictions.

Integrating blockchain with current infrastructure and processes presents a further formidable obstacle. Multiple parties are involved in the onion sector, and it may be difficult to ensure compatibility and interoperability across diverse systems and databases. This integration may need significant expenditures in new technology and infrastructure.

Regulatory concerns are crucial for blockchain adoption. It is necessary to handle data privacy and compliance with current requirements, such as data protection legislation. To guarantee that blockchain implementations comply with legal standards, developing new regulatory frameworks or altering current ones may be essential.

Additionally, unique traceability rules for the onion business must be addressed. Despite the fact that blockchain may improve traceability, integrating it with current traceability systems and satisfying regulatory criteria might be difficult. Resistance from stakeholders, such as worries about data security and competitive advantage, might inhibit blockchain implementation.

Particularly, farmers may be reluctant to reveal sensitive information. Through pilot projects and demos, educating stakeholders on the advantages of blockchain technology and addressing their concerns may help overcome opposition and promote acceptance.

By recognizing these problems and constraints to blockchain implementation in the onion sector, stakeholders may build mitigation solutions. Collaboration between industry participants, governments, and technology suppliers is essential for overcoming these obstacles and maximizing blockchain technology's promise in the onion sector.

Table 2. Challenges and barriers to blockchain adoption in the onion industry

Challenges and Barriers	Discussion
Technological Challenges	1. Scalability: The scalability of blockchain networks is a significant challenge in the onion industry due to the large volume of transactions. Existing blockchain platforms like Bitcoin and Ethereum have transaction speed and scalability limitations. However, newer platforms such as Hyperledger Fabric and Corda have been developed to address these scalability issues (Androulaki et al., 2018).
	2. Integration with Existing Infrastructure: Integrating blockchain with the existing infrastructure and systems in the onion industry can be complex. Collaboration and data sharing among multiple stakeholders require ensuring compatibility and interoperability between different systems and databases. This may involve significant investment in technology and infrastructure upgrades (NirKshetri, 2017; Han-Yu Xue et al. 2020).
Regulatory Issues	1. Data Privacy and Compliance: Blockchain's decentralized and transparent nature raises concerns about data privacy and compliance with existing regulations, such as data protection laws. Implementing blockchain may require the development of new regulatory frameworks or amendments to existing ones to ensure legal compliance while leveraging the technology's benefits (Maesa et al., 2020; Rajendran et al. 2023).
	2. Traceability Regulations: The onion industry may be subject to specific regulations and standards related to food safety and traceability. While blockchain can enhance traceability by providing an immutable record of the onion's journey, integrating blockchain with existing traceability systems and aligning it with regulatory requirements can pose challenges (Bhatta et al., 2020; Hulas Raj Tonday et al.2021; Kaaveya et al. 2020).
Resistance from Stakeholders	1. Data Security and Competitive Advantage: Stakeholders, including farmers, may be reluctant to share their data on a decentralized and transparent platform due to concerns about data security and maintaining a competitive advantage. Ensuring data security measures and addressing concerns related to competitive advantage are crucial for stakeholder acceptance (Lacity & Beck, 2018).
	2. Lack of Awareness and Understanding: Resistance to change and a lack of awareness about the benefits of blockchain technology can hinder its adoption. Educating stakeholders about blockchain's advantages and addressing their concerns through pilot projects and demonstrations can help overcome resistance and foster adoption (Kshetri, 2017; Swan, 2015).

Develop strategies to overcome the identified barriers to successfully adopting blockchain technology in the onion industry.

The ways to overcome impediments to implementing blockchain technology in the onion business are summarized in Table 3. These tactics include improving technology infrastructure, resolving regulatory compliance, and successfully involving stakeholders.

The table gives an organized framework with detailed goals, objectives, strategies, projected outcomes, and accountable parties for each specified topic.

This table provides a clear and accessible reference for stakeholders and policymakers to understand and execute effective steps to remove hurdles to blockchain adoption in the onion sector by tabularizing these initiatives.

These ideas, informed by relevant literature and industry knowledge, present a road map for supporting effective blockchain deployment, driving industry development, and capitalizing on the revolutionary potential of this technology.

3.4. Objective 1: Enhance Technological Infrastructure
3.4.1. Strategy 1: Enhance Scalability

Implementing off-chain techniques to circumvent scaling limits may boost transaction speed and decrease network congestion (Swan, 2015).

Exploring scaling alternatives for layer 2, such as state channels or sidechains, may help increase network capacity and decrease transaction costs.

3.4.2. Strategy 2: Ensure interoperability

Key efforts include the development of standardized APIs and protocols for smooth interaction across disparate systems and collaboration with industry partners to create interoperable blockchain solutions (Androulaki et al., 2018).

The objective of these initiatives is to enable data exchange and compatibility among parties.

Table 3. Propose a strategic plan for the implementation of blockchain technology in the onion industry

Plan	Objectives	Strategies	Expected Output	Responsible Person
1. Technological Infrastructure	1. Enhance scalability	1. Implement off-chain solutions for increased transaction speed	Improved scalability and throughput.	IT Department/ Blockchain Development Team
		2. Explore layer 2 scaling solutions (e.g., state channels, sidechains).	Enhanced network capacity and reduced transaction costs.	IT Department/ Blockchain Development Team
	2. Ensure interoperability	1. Develop standardized APIs and protocols for seamless integration.	Facilitated data sharing and compatibility.	IT Department/ Blockchain Development Team
		2. Collaborate with industry partners for interoperable blockchain solutions.	Streamlined communication and data exchange.	IT Department/ Blockchain Development Team
2. Regulatory Compliance	1. Engage with regulators	1. Establish industry-government collaborations for regulatory guidance.	Clear regulatory frameworks for blockchain adoption.	Management, Legal Department
		2. Participate in policy discussions and contribute expertise.	Influence regulatory decisions and ensure favorable conditions.	Management, Legal Department
	2. Implement privacy and data protection measures.	1. Utilize zero-knowledge proofs or homomorphic encryption for privacy.	Enhanced data privacy and confidentiality.	IT Department, Data Protection Officer
	2. Develop data governance frameworks and consent mechanisms.	Transparent data handling and compliance with data protection laws.	IT Department, Data Protection Officer	
3. Stakeholder Engagement	1. Conduct stakeholder education programs.	1. Organize workshops and training sessions on blockchain benefits.	Increased awareness and understanding.	Project Manager, Communication Team
	2. Create informational materials and case studies on successful blockchain implementations.	Showcase real-world use cases and benefits.	Project Manager, Communication Team	
	3. Foster industry-academia partnerships for research and knowledge sharing.	Enhanced expertise and collaboration	Project Manager, Communication Team	
	2. Address data security and competitive advantage concerns.	1. Implement robust access controls and encryption mechanisms	Secure data sharing and protection.	IT Department, Data Protection Officer
	2. Establish non-disclosure agreements to protect sensitive business information.	Maintained competitive advantage and trust	Legal Department	
	3. Collaborate with stakeholders to develop mutually beneficial incentives.	Encourage participation and data sharing.	Project Manager, Communication Team	

3.5. Objective 2: Regulatory Compliance
3.5.1. Strategy 1: Engage with Regulators

Engaging in industry-government partnerships and actively engaging in policy conversations might impact the creation of regulatory frameworks conducive to blockchain adoption (Bach et al., 2020). Such partnerships guarantee that the experience and viewpoints of the onion industry are considered in regulatory decisions.

3.5.2. Strategy 2: Implement Privacy and Data Protection Measures

Using sophisticated privacy-protecting methods such as zero-knowledge proofs or homomorphic encryption may increase the privacy and confidentiality of data (Maesa et al., 2020). Developing frameworks for data governance and consent methods increases compliance with data protection rules.

3.6. Objective 3: Stakeholder Engagement
3.6.1. Strategy 1: Conduct Stakeholder Education Programs

Organizing workshops and training sessions and creating informational materials and case studies help increase stakeholders' awareness and understanding of blockchain benefits (Lacity & Beck, 2018). Collaborating with academia enhances research and knowledge sharing.

3.6.2. Strategy 2: Address Data Security and Competitive Advantage Concerns

Implementing robust access controls, encryption mechanisms, and non-disclosure agreements safeguards data security and protects sensitive business information (Lacity & Beck, 2018). Collaborating with stakeholders to develop mutually beneficial incentives encourages participation and data sharing.

By implementing these strategies, the onion industry can proactively overcome barriers and pave the way for successful blockchain adoption. Collaboration among different departments, stakeholders, and industry experts is crucial for effectively implementing these strategies.

4. Conclusion

In conclusion, this study has shed light on the challenges and barriers to adopting blockchain technology in the onion industry in the Philippines. Through an analysis of technological, regulatory, and stakeholder-related factors, we have identified key obstacles that hinder the widespread adoption of blockchain in this industry. These barriers include technological limitations, regulatory compliance requirements, and stakeholder resistance.

Specific strategies have been proposed to overcome these barriers and foster successful blockchain adoption. These strategies encompass enhancing technological infrastructure, addressing regulatory compliance, and engaging stakeholders effectively.

By upgrading the blockchain platform, ensuring interoperability, collaborating with regulators, implementing privacy measures, conducting stakeholder education programs, and addressing data security concerns, the onion industry can overcome these barriers and harness the transformative potential of blockchain technology.

By integrating existing literature and industry expertise, this study provides a comprehensive framework for stakeholders and policymakers to understand and address the complexities associated with blockchain adoption in the onion industry. Implementing these strategies will enhance traceability, supply chain management, and quality assurance in the onion industry and open doors for innovation and improved efficiency.

It is important for stakeholders to recognize the significance of collaboration and coordination among industry players, policymakers, and technology providers. By working together and taking proactive steps to address the identified barriers, the onion industry can realize the full potential of blockchain technology, paving the way for a more transparent, efficient, and trustworthy onion supply chain.

Overall, this study serves as a valuable resource for decision-makers and practitioners in the onion industry who seek to navigate the challenges and leverage the opportunities presented by blockchain technology. By embracing these strategies, the onion industry in the Philippines can position itself at the forefront of technological advancements, fostering sustainable growth and competitiveness in the global market.

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