



The role of blockchain technology in ensuring food safety of Vietnamese culinary firms

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Abstract. In the context of the rapidly developing food and culinary industry, ensuring food safety has become a top priority in Vietnam. Blockchain technology, with its superior advantages in traceability, transparency, and information security, has opened new approaches to addressing food safety challenges in the culinary business. This study analyzes and evaluates the role of Blockchain technology in enhancing food safety, from improving agricultural supply chain management in Vietnam to facilitating the sustainable development of the culinary sector. Based on SWOT analysis, as well as practical applications of Blockchain in the agricultural, business, and financial fields in Vietnam, this research proposes solutions and recommendations for stakeholders, from researchers and managers to consumers, in applying Blockchain technology. Thus, the study aims to enhance safety, transparency, and efficiency in the food supply chain, contributing to the sustainable and environmentally friendly development of the culinary business in Vietnam.

Keywords: Blockchain technology, food safety, agricultural supply chain, culinary business, sustainable development.

1 Introduction

Food safety is one of the most critical factors for public health and sustainable economic development. In the culinary business industry in Vietnam, ensuring food safety not only contributes to improving consumer health and trust but also plays a pivotal role in enhancing Vietnam's position in the global food market. However, managing and controlling food quality from farm to table faces significant challenges, including traceability and quality control throughout the production and distribution process. Blockchain technology, known for its ability to provide a transparent, secure, and immutable information system, has opened new opportunities to address these challenges. The blockchain technology could be applied to manage the supply chain of

agricultural products in Vietnam can significantly improve traceability and ensure product quality, thereby enhancing transparency and food safety [1]. Some current challenges in ensuring food safety in Vietnam include detecting and managing issues related to food contamination, counterfeiting, and adulteration. These issues not only affect consumer health but also diminish trust in domestically produced food [2]. In this context, Blockchain technology provides a useful solution to enhance control and management of information related to the origin and production process of food.

Vietnam has recently witnessed increasing interest in the application of blockchain technology in various sectors, especially in food safety. This interest reflects not only the need to improve the quality and transparency of the food supply chain but also Vietnam's commitment to using technology to promote sustainable development. Below is an analysis of two prominent projects and specific applications of blockchain in the field of food safety in Vietnam. A prominent project using blockchain in food safety in Vietnam is the chicken product traceability project [3]. This project leverages blockchain technology to build a comprehensive and immutable traceability system, from production to consumer delivery. This not only enhances consumer trust in product quality but also strengthens transparency in the supply chain, reducing fraud and counterfeit products, thereby enhancing food safety in Vietnam. Application details are as follows:

Immutable record-keeping: Each stage of the supply chain, from breeding, caring, harvesting, processing, to distribution, is recorded on the blockchain, creating an unchangeable record. This helps eliminate fraud and enhance transparency.

Transparency and easy traceability: Consumers can easily trace the origin of the chicken products they purchase through a mobile app or website by scanning the QR code on the product packaging. Information about origin, care, and processing procedures, as well as food safety certifications, are accessible.

Enhanced consumer trust: Transparency and high traceability enable consumers to trust the quality and safety of chicken products.

Transparency: Blockchain provides consumers with access to immutable data on every stage of the supply chain, from breeding to processing to distribution. This helps reduce fraud and enhance transparency.

Produce traceability: Consumers can easily verify the origin of products by scanning QR codes, thereby increasing confidence in the quality and safety of food.

Cost reduction: Minimizing risks and fraud through the blockchain system helps businesses significantly save costs related to management and quality control of products.

Improving customer relations: Trust and confidence of consumers are improved, leading to loyalty, and expanding customer base.

Blockchain could be applied in the open information accounting system in Vietnam, based on the triple-entry accounting method [4]. Although not directly related to food safety, this study highlights the benefits of blockchain in creating a reliable and transparent platform for economic transactions, including in the food sector. Applying blockchain to accounting and financial management can improve tracking and control of product quality, thereby contributing to enhancing food safety. Application details are as follows:

- **Triple-Entry Accounting:** Applying the triple-entry accounting model, where each economic transaction is not only recorded by two parties but also confirmed on the blockchain. This creates a higher level of authentication and transparency for transactions.
- **Integration with existing accounting systems:** Blockchain technology is integrated into the open information accounting system, allowing businesses to track and manage product quality, capital, and finances accurately and transparently.
- **Security and data privacy:** Using blockchain helps protect financial information and other important data from the risk of hacking or fraud, thereby ensuring information security for businesses in the food industry.
- **Enhanced management and monitoring:** The system allows managers and investors to have in-depth and real-time insights into financial situations and product quality, enabling accurate and timely decision-making.
- **Transparent financial management:** Applying the triple-entry accounting model and recording transactions on the blockchain ensures that all financial information and product management are accurately and transparently recorded.
- **Quality control:** The transparency and reliability of the system help improve tracking and control of product quality, thereby contributing to enhancing food safety.
- **Process optimization:** Integrating blockchain helps automate and optimize accounting and management processes, minimizing errors and enhancing operational efficiency.
- **Enhanced security:** Information security and data are improved, reducing the risk of loss or manipulation of information, thereby protecting the assets and interests of businesses.

These projects and applications of blockchain in food safety in Vietnam open new opportunities to improve the quality and transparency of the supply chain. Applying blockchain helps Vietnam not only improve food safety for consumers but also strengthen its position in the international market with reliable and high-quality food products. The success of these projects encourages innovation and widespread adoption of blockchain technology in many other sectors of the economy, contributing to the country's sustainable development.

The objective of this study is to explore how Blockchain technology can improve food safety of the culinary industry in Vietnam by enhancing traceability and transparency in the food supply chain. By analyzing specific applications of Blockchain in managing the supply chain of agricultural products and food, the research aims to contribute to the development of technological solutions supporting food safety, thereby contributing to the sustainable development of the culinary industry in Vietnam.

Following this introduction, Section 2 reviews relevant theoretical backgrounds and empirical evidence, Section 3 presents the methodology and analyzes the results, and Section 4 concludes.

2 Literature review

2.1 Blockchain technology

Blockchain technology represents a fundamental change in how digital transactions are executed, recorded, and verified across various fields. Originating as the underlying infrastructure for cryptocurrencies, Blockchain has rapidly evolved into a versatile platform enabling secure, transparent, and immutable digital transactions.

Concept and development history of blockchain: Introduced alongside the emergence of Bitcoin in 2009, Blockchain technology was initially designed to tackle the issue of double-spending without the need for a trusted central authority [5]. Its core value lies in maintaining a distributed database and securing transactions, providing transparency to participating parties and resisting unauthorized changes. The potential of Blockchain technology extends far beyond cryptocurrencies, offering innovative solutions to traditional challenges in areas such as supply chain management, finance, healthcare, etc. [6]. Its evolution from a cryptocurrency assistant to a comprehensive platform for secure digital transactions marks a significant milestone in the history of digital technology.

Operation of Blockchain and key features: Blockchain operates based on a simple yet powerful principle: it is a distributed ledger that records transactions across a computer network. This ledger is composed of blocks, each containing a list of transactions and protected by encryption. Each new block is linked to the previous block, forming an unchangeable chain providing a complete and immutable history of all transactions on the network [7]. The integrity and security of this chain are maintained through consensus algorithms, ensuring all parties agree on the validity of transactions before they are added to the Blockchain. This distributed consensus mechanism eliminates the need for a central authority, minimizing the risks of fraud and corruption.

One of the prominent features of Blockchain is its immutability; once data is recorded on the Blockchain, it cannot be altered without consensus from most of the network. Combined with the transparency and security of Blockchain, this feature makes it an ideal platform for applications requiring high levels of trust and auditability. For example, in the supply chain field, Blockchain can be used to create a transparent record and combat counterfeiting regarding the journey of goods from manufacturers to consumers, enhancing trust and efficiency [8].

In summary, the core features of Blockchain technology - decentralization, immutability, and transparency - lay the foundation for it to become a transformative tool for executing secure, efficient, and trustworthy digital transactions across various fields.

2.2 Blockchain in the agricultural food supply chain

The application of Blockchain technology in the agri-food supply chain, both globally and in Vietnam, is opening new opportunities and solutions for the agriculture sector, especially in the context where transparency and high reliability are increasingly needed. In Vietnam, a typical example of Blockchain application in Vietnam is its

deployment in the rice supply chain, which is one of the nation's primary agricultural commodities. This project aims not only to enhance traceability of product origin from production to harvest and distribution but also to efficiently manage product quality. As a result, it helps to increase consumer trust in Vietnamese rice products, thereby expanding opportunities to access international markets [1]. The application of Blockchain in the agricultural sector in Vietnam helps establish transparency, allowing easy and accurate traceability of product origin. This not only enhances trust from consumers but also contributes to reducing fraud and enhancing product quality management. The transparency and reliability that Blockchain brings also help Vietnamese agricultural products increase their value in the international market, expanding opportunities for access and consolidating positions in the global market. Applying Blockchain in the global food supply chain helps create an immutable and easily verifiable information system, thereby building trust between consumers and producers [9]. This transparency not only helps consumers obtain detailed information about the origin and production process of products but also supports producers in proving the quality of their products, thereby enhancing credibility and competitiveness in the international market.

These examples and projects above not only demonstrate the potential of Blockchain technology to improve food safety but also highlight the necessity of applying this technology in modern agriculture. The application of Blockchain in the agri-food supply chain shows great potential in enhancing transparency, reliability, and product quality management. For Vietnam, further exploration and deployment of this technology will not only enhance the position of agricultural products in the international market but also establish strong consumer trust, thereby supporting the sustainable development of the domestic agricultural sector.

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2.3 Strengths, weaknesses, opportunities, and threats (SWOT)

A SWOT analysis provides a comprehensive view of the strengths, weaknesses, opportunities, and threats of applying Blockchain in the agriculture industry in Vietnam. This analysis delves deeper into the potential and specific challenges related to the application of Blockchain technology in the agriculture industry in Vietnam, emphasizing the improvement of transparency, product quality management, and the ability to expand international markets, as well as barriers related to resources, knowledge, and acceptance of new technology.

Strengths

- Enhanced transparency and traceability: Blockchain provide an immutable and fully transparent ledger system, facilitating traceability of product origin from farms to consumers. This not only increases consumer trust but also helps producers prove the quality of their products [10]; [7].
- Fraud reduction: Using Blockchain helps limit fraud and counterfeiting of products by providing accurate and unchangeable information about the production and distribution process, minimizing risks for both consumers and producers [11].
- Improved producer-consumer relationships: The traceability and transparency that Blockchain brings help build a trustworthy relationship between producers and consumers, thereby enhancing brand value and market reputation [12].

Weaknesses

- Resource and knowledge barriers: Implementing and deploying Blockchain technology requires deep understanding of the technology as well as significant financial resources to invest in the system and train personnel, which can be a major challenge for small and medium-sized enterprises in Vietnam [13].
- Acceptance of new technology: The transition from traditional management and operations systems to a Blockchain-based system requires time and may face opposition from stakeholders who are accustomed to conventional methods.

Opportunities

- Expansion of international markets: The application of Blockchain in the agriculture industry helps Vietnamese products meet international standards for transparency and quality, thereby expanding opportunities to access global markets and increasing export revenue [13].
- Support for sustainable agriculture: Blockchain can support initiatives related to sustainable agriculture by providing transparent information about production practices, environmental impact, and fair trade, thereby attracting environmentally conscious consumers [10].
- Efficiency and cost savings: Streamlining supply chain processes through Blockchain can lead to increased efficiency and cost savings by reducing paperwork, transaction costs, and intermediary fees, benefiting both producers and consumers [7].
- Increasing product value: Products managed with blockchain technology, with clear traceability, can attract a market segment willing to pay higher prices for guaranteed quality and food safety [8].
- Addressing supply chain issues: Blockchain technology has the potential to provide comprehensive solutions to existing challenges in the food supply chain in Vietnam. By enhancing traceability and transparency, blockchain helps minimize fraud and enhance consumer trust in product quality. The immutability and security of data on the blockchain ensure that all information from farm to table is accurate and reliable.

Threats

- Concerns about data security: Although Blockchain is renowned for its security capabilities, the issue of personal data security and sensitive information remains a challenge, especially when applied in the agricultural sector [14].
- Acceptance in traditional supply chains: Transitioning management and operational processes to a Blockchain system requires a change in mindset and working methods, demanding significant time and effort from all stakeholders in the supply chain [15].
- Technical challenges: One of the major barriers to adopting blockchain is the issue of scale and transaction speed. Current blockchain networks may not be fast enough to handle the large volume of data generated in the global food supply chain. However, the development of technologies like Blockchain 2.0 and layer 2 solutions is opening opportunities to overcome these challenges, enhancing the scalability and performance of blockchain.
- Legal and regulatory barriers: Applying blockchain in the food industry in Vietnam also faces legal and regulatory challenges. The lack of clarity in regulations may hinder the adoption of this technology. To overcome this, collaboration with regulatory agencies to develop a blockchain-friendly legal framework is necessary. This not only ensures compliance with regulations but also encourages innovation and technology adoption in the industry.

This SWOT analysis provides a comprehensive view of both the potential and challenges of implementing Blockchain technology in the agricultural sector in Vietnam. It emphasizes the importance of enhancing knowledge and skills in Block-

chain within the industry to fully leverage the benefits of this technology. By delving into specific examples and providing detailed SWOT analysis, this research expands understanding of the capabilities and barriers of Blockchain in the agri-food supply chain in Vietnam, while highlighting the urgent need for specialized expertise to effectively apply the technology.

In summary, while blockchain technology offers many opportunities to improve food safety and create a more level playing field for businesses in Vietnam, widespread adoption of this technology still faces technical and legal challenges. Close collaboration between businesses, government, and international organizations is needed to overcome these barriers and maximize the benefits of blockchain in the food industry.

2.4 Blockchain in food safety

Applying Blockchain technology to food safety management in Vietnam is gradually becoming an important field of research and practice, bringing many benefits while also facing numerous challenges. However, the potential and interest in Blockchain applications in food safety and agriculture in Vietnam indicate ongoing development and initiatives. Considering the rapid acceptance of technology and the significant agricultural sector in Vietnam, many projects are being implemented or in the planning stages.

For chicken products in Vietnam, stakeholders are allowed to trace the entire process from breeding, processing, to distribution, using Blockchain to ensure transparency and minimize fraud [3]. The potential of Blockchain could be applied to improve food safety management and emphasize how this technology can enhance reliability and reduce risks in the food supply chain, thereby contributing to improving food safety [12].

Tracing the origin of Vietnamese coffee

Vietnam, one of the world's largest coffee exporters, has a clear interest in ensuring the authenticity and quality of its coffee products. A Blockchain project could involve tracking the journey of coffee beans from farms through processing, export, and retail. This system will ensure that consumers worldwide can verify the origin of their Vietnamese coffee, potentially commanding higher prices for sustainably or organically certified beans. This not only enhances consumer trust but also supports fair compensation for farmers.

Smart Contracts for Seafood Export

Vietnam's seafood industry, crucial to the economy, stands to benefit greatly from Blockchain using smart contracts. These contracts can automate payment and certification when conditions such as delivery time, quality inspection, and environmental protection standards are met. The transparency of Blockchain means that all parties involved, from fishermen to international buyers, can trust in the fair and efficient enforcement of contracts.

Blockchain in the rice supply chain

Another potential application could be in the rice supply chain, like the chicken product traceability system [3]. A Blockchain system can track rice from fields to processing plants and exports, ensuring that all products meet Vietnam's high-quality and sustainable standards. This transparency can enhance Vietnam's reputation as a rice exporter and allow for higher pricing in the global market.

Ensuring safety for fruits and vegetables

Given the diversity of tropical fruits and vegetables in Vietnam, Blockchain can play a crucial role in verifying the safety and origin of these products. By recording every step in the supply chain, consumers can be assured of the quality and safety of the food they purchase, especially important for products exported to countries with strict import regulations.

Using Blockchain allows for transparent and accurate tracing of food origins, providing consumers with additional information when choosing products, while also assisting food managers in monitoring and managing product quality more effectively. Blockchain technology has the potential to minimize food fraud by providing an immutable ledger system, thereby enhancing trust and safety for consumers [16].

Although Blockchain is renowned for its high security, concerns about the security of personal data and sensitive information still exist, especially in storing and accessing data on public blockchains [14]. One of the major challenges in implementing Blockchain is the acceptance by traditional management systems. Transitioning to a new system requires time, cost, and changes in work processes, as well as attitudes and mindset from stakeholders [15].

3 Methods and Results

3.1 Methodology

In this research section, a qualitative research method is applied to gain a deeper understanding of the application of Blockchain technology in the agricultural sector in Vietnam. This approach allows us to synthesize and analyze data from various sources, including recent case studies, articles, and published reports, to provide comprehensive insights into the topic.

Criteria for case studies include:

- **Modern and relevant:** We select case studies based on their modernity and relevance to the topic of applying Blockchain technology in the agricultural sector in Vietnam. This ensures that the information analyzed and presented is up-to-date and highly practical.
- **Diversity:** To provide a comprehensive view, we focus on selecting case studies from various sources that reflect a range of Blockchain applications in agriculture, from supply chain management to origin tracing and food safety.

- Feasibility and impact: Priority is given to case studies that are highly feasible and have either achieved or have the potential to create positive impacts on the agricultural sector in Vietnam.

Analyses include:

- Content analysis: We apply content analysis to evaluate and synthesize information from the selected case studies. This process involves identifying key themes, patterns, and trends related to the application of Blockchain technology in agriculture.
- Comparison and contrast: Case studies are compared with each other to identify similarities and differences, thereby drawing lessons learned and insights into the potential as well as challenges of applying Blockchain.
- Evidence-based evaluation: Each case study is evaluated based on empirical evidence and achieved effectiveness to determine the applicability and practical value of Blockchain technology in the specific context of Vietnam's agricultural sector.

This qualitative research methodology allows us to provide in-depth and comprehensive insights into the application of Blockchain technology in the agricultural sector in Vietnam, while also suggesting directions and strategies for stakeholders in the future.

3.2 Analytical results

Blockchain technology is considered a significant innovation that enhances food safety and traceability in the food industry, an important sector in Vietnam, renowned for its rich culinary heritage. This technology not only promises to revolutionize how food quality is monitored and managed but also brings a host of unique challenges and opportunities in the Vietnamese context. Below, we will delve into exploring the benefits, challenges, and opportunities that Blockchain brings to food safety in Vietnam's food industry, through comparison with global research insights.

Benefits

Internationally, Blockchain is praised for its potential to revolutionize supply chain management by ensuring traceability and transparency [17]. It enables stakeholders to access real-time information about the journey of food products from farm to table, thereby enhancing food safety and minimizing fraud. In Vietnam, applying Blockchain to agricultural food supply chains can significantly improve the traceability of local products such as pepper, cashews, and coffee. This not only enhances consumer trust but also aligns with global food safety standards, giving Vietnamese products a competitive edge in the international market [1].

Studies have shown how Blockchain technology helps optimize supply chain processes, significantly reducing costs and transaction times, as well as improving overall supply chain efficiency. For Vietnamese food businesses, leveraging Blockchain can lead to more efficient supply chain operations, with improved coordination between farmers, processors, distributors, and retailers. This not only ensures the quality and safety of food products but also reduces waste and optimizes resource utilization, contributing to sustainable business practices.

Challenges

Deploying Blockchain technology requires complex technical requirements and significant collaboration among stakeholders. This complexity is further compounded by the need for technical expertise and substantial initial investment, posing challenges for many Vietnamese businesses, especially small and medium-sized enterprises (SMEs). The lack of comprehensive policies and standards is a significant barrier to implementing Blockchain in the food industry. Developing a regulatory sandbox and industry standards is crucial to fostering innovation while ensuring food safety and consumer protection. Aligning with international standards and integrating Blockchain into existing legal frameworks remains a challenge for Vietnam. Collaboration between government agencies, industry stakeholders, and technology experts is necessary to create a conducive environment for Blockchain adoption.

Opportunities

Applying Blockchain technology can significantly contribute to the sustainable development of Vietnam's agriculture industry, aligning with the United Nations Sustainable Development Goals (SDGs). By enhancing traceability and transparency, Blockchain supports sustainable agricultural practices, fair trade, and environmental responsibility. Vietnam is currently a high-potential market for Blockchain development, especially as the country focuses on digital economy policies. Blockchain technology can play a crucial role in modernizing the food industry, improving food safety standards, and positioning Vietnam as a leading player in the global digital economy.

Summary

Integrating Blockchain technology into Vietnam's food industry opens a promising path to address critical issues related to food safety, traceability, and supply chain efficiency. Despite the challenging journey, including technical complexities and the need for legal progress, the potential benefits outweigh these barriers. Drawing from international research and practices, Vietnam can overcome these challenges, leverage Blockchain to enhance food safety, promote sustainability, and seize the opportunities brought by the digital economy. In doing so, Vietnam can position itself as a leader in Blockchain innovation in the food industry, both regionally and globally.

4 Concluding remarks

This research has explored and elucidated the pivotal role of blockchain technology in enhancing food safety and fostering sustainable development in Vietnam's food industry. Blockchain technology, with its capability to enhance transparency and traceability, has demonstrated positive impacts on building consumer trust and improving supply chain management efficiency. This not only helps strengthen food safety but also supports Vietnam in reshaping and elevating its position in the global food market.

While applying Blockchain technology to the food industry in Vietnam, developing smart policies and providing detailed recommendations will be key to achieving innovation while ensuring safety and transparency. Below is an expanded set of policy proposals and recommendations at a higher level of detail.

Blockchain has been proven to be a game-changing tool in enhancing traceability and transparency in the food supply chain, thereby driving the process of improving food safety. The application of this technology provides the ability to closely monitor from the point of origin to the end consumer, reducing the risk of fraud and enhancing consumer trust. Blockchain technology has demonstrated its ability to innovate supply chain management, from origin to point of sale, thereby increasing food safety for consumers [18]. To support the widespread deployment and adoption of Blockchain technology, upgrading and reforming the existing policy and legal system becomes extremely important. This includes clearly defining standards and regulations related to privacy rights, data security, and information access, to create conditions for a fair and transparent environment [19]. Collaboration between government, businesses, and educational institutions in developing and implementing in-depth training programs on blockchain is crucial to enhance knowledge and skills in applying this technology in the food industry. Training programs need to include both theory and practice, helping to improve capabilities for both workers and managers, thereby optimizing the deployment and use of blockchain technology in food safety [20].

Blockchain offers great opportunities for Vietnam to improve the quality and safety of food through enhanced traceability and transparency. To maximize these benefits, Vietnam needs to prioritize updating and developing supportive policies, legal frameworks, and standards. Investing in the development of training programs and enhancing skills for stakeholders is key to successfully implementing blockchain technology, not only improving the quality and safety of food but also contributing to enhancing Vietnam's competitiveness in the international market. Collaboration and commitment from the government, businesses, and educational institutions will lay a solid foundation for innovation and sustainable development in the food industry of Vietnam.

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