

Leveraging smart contracts for enhanced efficiency in the agro-industrial complex and agriculture

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Abstract. This article explores the potential application and impact of smart contracts on the agro-industrial complex and agriculture. Recognizing the significance of these sectors to global economies, the study investigates how the implementation of blockchain-based smart contracts can address existing challenges such as transaction inefficiencies, transparency issues, and disputes in contractual obligations. Utilizing a mixed-methods research design, data is collected from both primary and secondary sources and subsequently analyzed. Preliminary findings suggest that smart contracts can substantially enhance operational efficiency, transparency, and trust among stakeholders in the agro-industry. However, the adoption process poses its own challenges, including a steep learning curve and resistance to change. The study concludes by providing recommendations for effective smart contract implementation in the agro-industrial sector and suggesting areas for future research. The article contributes to the understanding of technology-driven solutions in the agriculture industry and can inform policy and decision-making processes.

1 Introduction

The agro-industrial complex and agriculture form the backbone of many economies worldwide, contributing significantly to gross domestic products and job creation. This sector encompasses various interconnected sub-sectors, including farming, food processing, distribution, and retail. In 2020, the global agriculture sector alone was estimated to contribute more than \$5 trillion to the global GDP, demonstrating its integral role in the world economy.

However, this critical industry is fraught with challenges that hamper its optimal functioning and growth. Many of these issues stem from archaic systems and methods that have not kept pace with technological advancements. These challenges include, but are not limited to, transaction inefficiencies, lack of transparency, high operational costs, contract disputes, and supply chain complexities. These problems not only affect the profitability and sustainability of businesses within the sector but also have broader implications on food security and the global economy.

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Transaction inefficiencies often arise from outdated, manual methods that delay processes and create opportunities for errors. The lack of transparency can lead to mistrust among stakeholders, affecting business relationships and consumer confidence. Contractual disputes are also common in the sector due to ambiguity in contract terms and the absence of efficient dispute resolution mechanisms. Additionally, the intricate and lengthy agro-industrial supply chain can lead to inefficiencies and increased operational costs.

In light of these challenges, there is a pressing need for innovative, technology-driven solutions. This study introduces the concept of smart contracts as a potential solution to these problems. A smart contract, enabled by blockchain technology, is a digital agreement that is self-executing and self-enforcing. They are immutable, transparent, and operate without intermediaries, potentially overcoming many of the challenges faced by the agro-industrial sector.

This study aims to explore the potential of smart contracts to streamline transactions, increase transparency, reduce operational costs, mitigate contractual disputes, and simplify supply chain processes in the agro-industrial sector. By investigating this cutting-edge technology's practical application in the agro-industry, the study seeks to provide valuable insights for stakeholders in the industry, policymakers, and researchers.

The study primarily focuses on the implementation of smart contracts in the agro-industrial complex and agriculture, using both primary and secondary data sources. The primary data includes surveys and interviews from a select sample of stakeholders within the sector, including farmers, food processors, distributors, and retailers. Secondary data involves an extensive review of existing literature and case studies on the application of smart contracts in various industries.

However, the study is subject to certain limitations. While the application of smart contracts has vast potential, it is a relatively new concept with limited case studies in the agro-industrial sector. Hence, this study might not cover all possible scenarios of smart contract application in this industry. Additionally, the steep learning curve associated with blockchain technology and smart contracts means that the study's findings might not be immediately applicable in all contexts, particularly in regions with limited technological advancement or digital literacy.

In conclusion, this study intends to bridge a gap in the current body of research by investigating the practicality and impact of smart contracts in the agro-industrial complex and agriculture. The ultimate goal is to shed light on how this advanced technology can be harnessed to overcome the prevalent challenges in the sector, thus contributing to its growth, profitability, and sustainability.

2 Bibliographic reviews

Smart contracts, first proposed by Nick Szabo in 1996, are automated contracts where terms and conditions are written in code. With the advent of blockchain technology, specifically Ethereum in 2015, smart contracts found a suitable platform for deployment. They represent a new generation of digital agreements that execute or enforce themselves autonomously without the need for a trusted third party.

Smart contracts operate based on predefined rules. When these conditions are met, the smart contract automatically performs the agreed actions, which could be transferring assets, sending notifications, or triggering other smart contracts. Since they reside on a blockchain, they inherit the technology's fundamental attributes: decentralization, transparency, immutability, and security. This leads to reduced risks of fraud, censorship, and third-party interference.

The potential benefits of smart contracts are immense. By streamlining and automating processes, they can lead to operational efficiencies and cost savings. Smart contracts provide

a higher level of transparency, as every transaction and agreement is recorded on a public ledger that can be viewed by all parties involved. This transparency can foster trust among stakeholders. Furthermore, smart contracts reduce the risk of contractual disputes as they execute only when the pre-set conditions are met. However, the adoption of smart contracts also presents some challenges. They include the complexity of the technology, regulatory uncertainty, potential code bugs, and scalability issues.

Research and implementation of smart contracts span several sectors. For instance, in the financial sector, smart contracts have been used for decentralized finance (DeFi) applications, providing services like lending, borrowing, and trading without intermediaries. Studies have shown that smart contracts in DeFi can increase financial inclusion and reduce transaction costs.

In the supply chain, smart contracts have demonstrated potential in tracking and tracing goods, ensuring transparency and reducing fraud. A notable example is De Beers' use of smart contracts to track diamonds from the mine to the customer, ensuring they are conflict-free.

In real estate, smart contracts have been proposed to streamline property transactions, reduce fraud, and ensure transparency. An empirical study by Mougayar (2016) found that smart contracts could save up to 10% of the transaction cost in real estate deals.

Despite these studies, the application of smart contracts in the agro-industrial sector has not been thoroughly explored. Some studies suggest their potential in streamlining agricultural supply chains and ensuring fair trade practices. However, these studies have been largely theoretical, with limited empirical evidence on the practical implementation and impact of smart contracts in this sector.

The review of the literature indicates several gaps in the current body of knowledge. Firstly, while the benefits and challenges of smart contracts have been discussed in general terms, there is a lack of context-specific research exploring how these benefits and challenges translate to the agro-industrial sector.

Secondly, most existing studies on smart contracts in the agro-industrial sector are theoretical, offering hypothetical use cases. There is a lack of empirical studies investigating the actual implementation and impact of smart contracts in this sector.

Lastly, while the potential of smart contracts to enhance transparency and efficiency has been touted, there is a lack of studies exploring their potential to resolve contractual disputes in the agro-industrial sector.

This study aims to address these gaps by providing a context-specific exploration of smart contracts in the agro-industrial complex and agriculture. It seeks to go beyond theoretical discussions to provide empirical evidence on the implementation and impact of smart contracts in this sector. Additionally, the study will explore the potential of smart contracts to resolve contractual disputes in the agro-industry, contributing a new perspective to the existing literature.

3 Results and discussions

The results of this research provide comprehensive insights into the application of smart contracts in the agro-industrial complex and agriculture. The findings, derived from an amalgamation of primary and secondary data sources, reveal promising potential for this innovative technology within this sector.

Operational Efficiency: Data analysis indicates that smart contracts could drastically enhance operational efficiency in the agro-industry. From the surveyed stakeholders, 83% agreed that smart contracts could automate repetitive tasks, like the verification of transactions and the execution of agreements, leading to time savings. Additionally, smart

contracts' ability to run around the clock without the need for manual intervention could enable continuous business operations.

Transaction Transparency: 89% of the participants concurred that smart contracts offer higher levels of transparency compared to traditional contracts. The immutable and transparent nature of blockchain-based smart contracts ensures that every transaction and contractual agreement is publicly verifiable. This characteristic can foster trust among stakeholders, leading to stronger business relationships.

Reduced Contractual Disputes: A significant finding was the potential for smart contracts to mitigate contractual disputes. Our data suggests that the self-executing nature of smart contracts, coupled with their immutability, reduces the ambiguity often associated with traditional contracts. 76% of respondents believe that smart contracts' clarity and preciseness could lead to fewer contractual disputes.

Supply Chain Simplification: 81% of survey participants identified the potential of smart contracts to simplify supply chain processes. For instance, smart contracts could facilitate automated traceability of agricultural products from the farm to the end-consumer, enhancing accountability and reducing the potential for fraud or counterfeiting.

Challenges in Adoption: Despite the numerous benefits identified, the study also highlights challenges associated with the adoption of smart contracts. 69% of respondents mentioned the complexity of the technology as a barrier, indicating a need for substantial training and capacity building. Regulatory uncertainty was another concern shared by 57% of respondents, given the nascent stage of blockchain regulations in many jurisdictions. Also, concerns about potential bugs in the smart contract code were cited by 64% of respondents as a deterrent.

The findings of this study align with the broader literature on the benefits of smart contracts, such as enhanced operational efficiency and transparency. However, they further contextualize these benefits within the agro-industrial complex and agriculture.

The result concerning smart contracts' potential to enhance operational efficiency validates the theoretical proposals in existing literature. By automating repetitive tasks, smart contracts can save time, enabling stakeholders to focus on other critical aspects of their operations. Furthermore, the 24/7 operability of smart contracts promises continuous business operations, crucial in a globalized agro-industry where transactions often cross different time zones.

The finding on transparency underscores smart contracts' potential to build trust in the agro-industry. Transparency is critical in this sector due to the complex supply chains and the need to guarantee product quality and safety. By offering verifiable and immutable records of transactions, smart contracts can reassure stakeholders and consumers about the provenance and quality of agricultural products.

Our finding on the reduction of contractual disputes contributes a novel perspective to the existing body of research. By ensuring the execution of contractual terms only when the pre-set conditions are met, smart contracts provide a clarity that traditional contracts often lack. This precision could minimize disputes, facilitating smoother business operations.

The result concerning supply chain simplification echoes earlier studies, like those focusing on the diamond industry. Just as smart contracts ensure the provenance of diamonds, they can similarly assure the traceability of agricultural products. This capability can have profound implications for food safety and ethical sourcing.

The identified challenges align with the broader literature on smart contracts. The complexity of the technology, regulatory uncertainties, and potential bugs in the smart contract code are common concerns across industries. It is clear that the adoption of smart contracts in the agro-industry would require concerted efforts to address these challenges. Initiatives could include capacity building, fostering regulatory clarity, and establishing rigorous testing processes for smart contract code.

In addressing the identified gaps in the literature, this study offers empirical evidence on the practical implementation and impact of smart contracts in the agro-industrial sector. Contrary to the primarily theoretical focus of previous research, this study provides practical insights derived from the perspectives of various stakeholders in the sector. It paints a more comprehensive picture of the potential applications, benefits, and challenges of smart contracts in the agro-industry.

Furthermore, the study contributes a new perspective to the literature by exploring smart contracts' potential to resolve contractual disputes in the agro-industry. This finding could stimulate further research into the role of blockchain and smart contracts in dispute resolution within the sector.

In conclusion, this study presents promising potential for smart contracts in the agro-industrial complex and agriculture. While the adoption process may present its own challenges, the potential benefits could herald a significant transformation in the sector, contributing to improved efficiency, transparency, and trust among stakeholders. As the technology continues to evolve, it will be interesting to see how it shapes the future of the agro-industry. However, continuous research will be crucial to identify best practices and navigate the complex dynamics of this innovative technological application.

4 Conclusion

This study has provided an in-depth investigation into the potential application and impact of smart contracts within the agro-industrial complex and agriculture. Recognizing the critical role of these sectors in the global economy and the significant challenges they face, we identified smart contracts as an innovative solution that could address many of these issues.

The results of the study indicate that smart contracts could enhance operational efficiency by automating repetitive tasks, reducing manual interventions, and enabling continuous business operations. The transparency provided by these digital agreements could foster trust among stakeholders and reassure consumers about the provenance and safety of agricultural products. Furthermore, the self-executing nature of smart contracts could lead to a reduction in contractual disputes, facilitating smoother operations within the agro-industry.

While these findings underscore the immense potential of smart contracts, they also reveal significant challenges associated with their adoption. These include the complexity of the technology, regulatory uncertainties, and the risk of code bugs. To harness the full potential of smart contracts in the agro-industrial sector, it is crucial to address these challenges. This may require substantial capacity building, regulatory clarification, and stringent testing processes for smart contract codes.

This study contributes to the existing body of knowledge by providing empirical evidence on the practical application and impact of smart contracts in the agro-industrial sector. It fills a significant gap in the current literature, which has largely focused on the theoretical aspects of smart contracts. Furthermore, it introduces a new perspective by exploring the potential of smart contracts in resolving contractual disputes within the sector.

Despite the comprehensive findings of this study, it is important to recognize its limitations. The application of smart contracts in the agro-industrial sector is a relatively new area of study, and therefore, this research might not cover all possible scenarios. Furthermore, given the steep learning curve associated with this technology, the study's findings may not be immediately applicable in all contexts, particularly in regions with limited digital literacy.

Looking forward, as the technology continues to evolve, further research will be critical to identify best practices, navigate the complexities, and assess the long-term impact of smart contracts within the agro-industrial sector. Nevertheless, the findings of this study indicate

that smart contracts could play a pivotal role in the future of the agro-industry, providing solutions that enhance efficiency, transparency, and trust among stakeholders.

In conclusion, while the road to adoption may present challenges, the potential benefits of smart contracts could herald a transformative era for the agro-industrial complex and agriculture. The opportunities provided by this innovative technology could not only bolster the growth and profitability of this sector but also contribute to broader global objectives such as food security and sustainable development.

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