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The role of Blockchain Technology in enhancing sustainability of Supply Chains: Perspectives from Brazil's pharmaceutical Industry

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Abstract

The pharmaceutical supply chain faces significant sustainability challenges, including inefficiencies, waste, counterfeit drugs, and regulatory compliance issues. This paper explores the role of blockchain technology in addressing these challenges and enhancing the sustainability of pharmaceutical supply chains. Firstly, the primary sustainability challenges are identified, highlighting inefficiencies, environmental impact, and issues related to transparency and traceability. Secondly, the paper also examine specific mechanisms through which blockchain technology can improve sustainability, such as enhancing transparency, reducing waste, and ensuring the integrity of the supply chain through immutable records and smart contracts. Lastly, a comparative analysis is conducted to evaluate the effectiveness of blockchain technology against other emerging technological solutions in enhancing sustainability within pharmaceutical supply chains. The paper uses content analysis as well as case studies to explore literature related to supply chain sustainability and application of block chain technology.

1.1 Introduction

Blockchain is one of the technologies that has revolutionized the contemporary world, making it possible to store information in a decentralized, anonymous, secure, transparent, and immutable way (Sahoo et al. 2022). These characteristics have been widely used to create digital currencies such as bitcoin, but this is just one of the few possible applications for this tool (Kshetri, 2021). Most recently researchers began to take an interest in its uses in the supply chain (SC) and its impact on sustainability (Parmentola et al., 2022, Njualem 2022, Sahoo et al. 2022). The application of block chain in the pharmaceutical supply chain has also received fair attention from academia and the majority of research papers link supply chain sustainability with implementation of block chain technologies along the value chain. Apart from general waste,

pharmaceutical supply chains have unique complex sustainability challenges such as drug expiry as well as counterfeit products. There is need provide a synthesis of literature to explore the importance of block chain technology in the pharmaceutical sector while at the same time considering its impact on sustainability.

Seyed et al., (2021) discovered that block chain technology is critical to sustainable performance of pharmaceutical cold chain, taking into consideration its complexity and sensitivity. The the contribution of block chain technology in pharmaceutical cold chain sustainability is based on the technology´s capability to provide pharmaceutical digital identity, serialization and traceability, data integrity, transparency, and waste management. Applications of blockchain in pharmaceutical data integration prevent resources to be wasted by tracing the temperature of products consequently at any step of the logistic process, protect information from being stolen or changed, and creates a competitive advantage.

Mainly, blockchain brings noticeable benefits such as serialization, tracing, securing IoT devices, smart contracts, avoiding counterfeiting, and temper-proof information sharing systems (Kshetri, 2021).

While block chain technology has been widely discussed based on its potential to streamline supply chain operations, its application has been minimum owing to several factors such as compatibility cost as well as regulatory barriers. However, there are wide range of alternative emerging technologies which have also received wider application in supply operations artificial intelligence, IoT, cloud computing and robotics. Kshetri (2021) noted the complimentary nature of emerging technology in enhancing sustainability and went on to single out blockchain for its ability to provide a developed and recognized decentralized system, where any transactions will be stored and recorded permanently, including a timestamp component.

There is need to explore literature on how block chain technology enhances sustainability and how other emerging technologies complement and replicate block chains in enhancing sustainability of pharmaceutical supply chains. Hence the following research questions.

1.2 Main research question

What is the role of block chain technology in enhancing sustainability of pharmaceutical supply chains?

1.2.1 Specific research questions.

RQ1 What are the primary sustainability challenges faced by pharmaceutical supply chains.

RQ2 What are the specific mechanisms through which blockchain can enhance sustainability pharmaceutical supply chains.

RQ3 How does the effectiveness of blockchain technology in enhancing sustainability in pharmaceutical supply chains compare to other emerging technological solutions.

1.3 Literature review

1.3.1 Sustainability challenges in pharmaceutical supply chains

Due to chemical nature of the medications and the dangerous impacts of medicine wastes on the environment and human health, outdated medications, and the need for proper waste management in the pharmaceutical supply chain, the use of emerging technologies remain necessary. Uncertainty of demand and the limited shelf-life of medications increase the risk of remaining surplus/outdated items and facing a high volume of pharmaceutical waste in the supply chain (Luna & Viana, 2019).

Other critical challenges related to outdated medications include their disposal. As the pharmaceutical products include biologically active and frequently toxic substances, the disposal of leftovers/outdated medications is also complicated and endangered the environment, particularly if the wastes disposed of improperly (Carvalho & Barbieri, 2013). Researchers such as Al-Awamleh et al. (2022) and Ding (2018) also highlight strict regulations on the traceability of medicines, their raw materials and waste disposal as one of the main challenges in this supply chain.

1.3.2 Application of block chain in enhancing sustainability

Blockchain technology is transforming the pharmaceutical industry by enhancing transparency, traceability, and security throughout the supply chain (Uddin 2021). By creating immutable records of every transaction, blockchain ensures the authenticity of pharmaceutical products, combating the pervasive issue of counterfeit drugs. A study by Khan et al., (2021) discovered how block chain technology can allow for precise tracking of drugs from production to delivery, enabling real-time visibility into the origin, composition, and handling of pharmaceutical products. Recently Bamakan et al. (2021) reported how further innovation in block chain has incorporated smart contracts which can streamline processes by automating and enforcing agreements and ensuring compliance with regulatory requirements. Despite their slow uptake, blockchain facilitates secure and efficient sharing of sensitive data among stakeholders, from manufacturers and distributors to healthcare providers and regulatory bodies, thereby improving coordination and trust.

1.4 Methodology

The paper uses content analysis and case study following logical systematic steps.

1.4.1 Content Analysis

The paper also relies on reputable papers relevant to research objectives. The research makes use of IEE, Web of Science and Scopus for searching literature. These databases have been selected based on their reptation and they have wide coverage of research in technology, sustainability, and supply chain management. There is high use of high-quality publications ascertained by peer review process. For quality and relevance, papers published between 2016 and 2023 were used. Publications covering both supply chain management and Block chain technology first appeared together in 2016 on the Scopus database (Njualem, 2021). To ensure that only relevant publications are included, Pharmaceutical Supply chain sustainability, Block chain technology, and emerging technologies were used as key search words.

1.4.2 Case study of Brazil pharmaceutical industry

To gain in-depth, understand on the application of bock chain technology in Brazil pharmaceutical industry, case study will be applied focusing primarily on the drug manufacturing and retail organizations. This approach is crucial for understanding the unique challenges and opportunities faced in terms of block chain application with the sector. We will explore the use of block chain technology in tackling sustainability challenges such as, outdated medications, counterfeit drugs, and the need for proper waste management. Interviews will be used to collect qualitative data which will be analyzed using thematic analysis.

1.5 Expected Findings and Discussion

Expected results on sustainability challenges facing pharmaceutical supply chain include waste management stemming from disposal of leftovers from the production process of medicines and expired drugs(Wedha et al., 2023). Other challenges include proliferation of counterfeit drugs (N. et al., 2024). In terms of operations, the use of block chain technology is likely to enforce traceability of drugs as well as maintaining transparent data base resulting in improved sustainability (Hamid et al., 2023). While block chains have different mechanisms from other emerging technologies such as AI, their application in sustainable pharmaceutical supply chains is complimentary.

1.6 Contribution to theory and practice

The papers provide clues and directions for future research to enrich studies on the role of block chain technology in pharmaceutical supply chain. In terms of practice, the paper contributes to adoption of block chain technology in enhancing stainability through analysis of benefits related to adoption.

1.7 Conclusions

This paper investigates the importance of block chain technology on sustainability of the pharmaceutical industry's supply chain as well as comparison of block chain application with other emerging technologies. Based on expected findings we conclude that block

chain technology has the potential to enhance sustainability within pharmaceutical supply chains. Block chain can complement other emerging technologies such as AI in providing practical solutions to sustainability challenges. This work also has limitations in terms of the methodologies used. Since the application of block chain technology in supply chain is new, literature on the subject matter is still scarce and this limits generalizability of findings. Future research may make use quantitative analysis to investigate the effect of block chain technology on sustainability performance and compare the impact in different countries.

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Molde University College
Specialized University in Logistics

HiMolde PhD

DRL028 Blockchain Applications in SCM

Credits: **5 ECTS**

Time: **27 – 31 May 2024**

The course covers fundamental concepts within blockchain technologies (BC) and their applications in supply chain management (SCM). Examples include historical perspectives, BC basics, basic cryptography, peer-to-peer transactions, BC structure, monetary policy and mining, forks and attacks, beyond bitcoin, Ethereum, smart contracts, and enterprise BCs.

Day 1 – May 27, 2024

Welcome & introduction (Bjorn, Anolan, Nitin, Arvind, Alok, Terje)

Each student presents him/her-self, thesis topic and motivation for blockchain (10 min each)

How to Use Publication to Advance Your Academic Career: An International Perspective! (Arvind)

It's All About Collaboration (Research Approaches) (Arvind)

Converting Your Research into a Paper for Publication! Present organization of groups (Alok, Arvind)

Lecture: Blockchain technology and SCM (by Nitin)

Blockchain-SCM Project: Ideas for seminar working paper (led by Alok)

Day 2 – May 28, 2024

Task 1, 2 and 3 Presentations with discussions (max 30 min for each)

Lecture: Blockchain technology and SCM (by Nitin)

Blockchain-SCM Project: Identify a research focus area & gap identification (led by Alok)

Day 3 – May 29, 2024

Task 4, 5 and 6 Presentations with discussions (max 30 min for each)

Lecture: Blockchain technology and SCM (by Nitin)

Blockchain-SCM Project: Research Approach/Method

Day 4 – May 30, 2024

Task 7 and 8 Presentations with discussions (max 30 min for each)

Lecture: Blockchain technology and SCM (by Nitin)

Lecturers presenting their research on Blockchain in SCM (15 min for each)

Blockchain-SCM Project: Working paper writing (led by Alok)

Day 5 – May 31, 2024

Blockchain-SCM Project: Working paper writing (led by Alok)

Blockchain-SCM Project: Presentation of working paper (by each PhD student)

Summing up

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