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Enhancing Consumer-to-Consumer (C2C) E-Commerce through Blockchain: A Model-Driven Approach

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Abstract **-** The rapid progress of Information and Communication Technology (ICT), especially the Internet, has changed lifestyles in profound ways, including sharing ideas, virtual interactions, digital entertainment, and online transactions. It has resulted in businesses globally turning to electronic commerce (e-commerce) to market products. E-commerce has revolutionized operations with features such as centralized storage and detailed product information in the marketing process. However, the inefficiency and lack of transparency in these centralized systems lead to high costs and limited user control, posing a significant challenge. Challenges include commission fees from E-Commerce providers, which hinder business growth. The research aimed to propose a more efficient and transparent model for Consumer-to-Consumer (C2C) e-commerce using blockchain technology. The C2C model enhanced user transactions and minimized third-party dependence, but centralization increased costs and limited seller access. Thus, a decentralized blockchain approach was proposed for greater transparency in e-commerce. The research innovatively applied blockchain to C2C e-commerce, enhancing market efficiency and transparency. The research method appliyed was a combination of Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis and practical application. The result shows that the approach succeeds in reducing high costs, transparency of data storage, and dependence on third parties. Blockchain reduces third-party involvement and promotes a fairer business environment because it uses a tamper-proof database for transparency, security, and efficiency in the ever-growing e-commerce ecosystem. Blockchain ensures automated transactions, real-time data tracking, and data security.

Keywords: Consumer-to-Consumer (C2C), e-commerce, blockchain, model-driven approach

I. INTRODUCTION

The widespread use of Information and Communication Technology (ICT), especially the Internet, has led to lifestyle changes, including online interactions and electronic commerce (e-commerce) adoption by businesses globally. E-commerce represents a revolutionary era that transforms managed and marketed enterprises and facilitates their growth (Bulsara & Vaghela, 2020). However, this shift has not been without its challenges. The inefficiencies and transparency issues in centralized e-commerce systems have highlighted an urgent need for innovative solutions, such as blockchain technology. E-commerce introduces novel features, including consolidating all goods onto electronic platforms and offering detailed product information (Shorman et al., 2019). Consequently, e-commerce addresses financial transactions and serves as a medium for exchanging product information stored centrally by an authorized institution or organization (Shorman et al., 2019). However, central management poses access restrictions based on predefined criteria, necessitating

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alternative approaches to eliminate organizational authority (Ismanto et al., 2019).

E-commerce is challenged by commission fees imposed by its facilitators or providers (Zhu & Wang, 2019), deterring sellers from expanding their reach to various buyer sectors (Shorman et al., 2019). The Consumer-to-Consumer (C2C) business model facilitates user interactions in buying and selling goods and services (Shorman et al., 2019). It aims to reduce reliance on third parties that validate transactions, thereby decreasing administrative costs by platforms and avoiding potential monopolies from platform providers (Miraz & Ali, 2018). However, centralized C2C models necessitate additional promotional expenses by platform operators, leading to price hikes and hindering access for sellers unable to afford such promotions. A more transparent sales process is required to prevent the concentration of power and mitigate promotional costs to address this issue (Miraz & Ali, 2018). It is crucial to implement a decentralized e-commerce system, such as blockchain technology, to achieve heightened data transparency and forestall potential monopolies in the e-commerce landscape.

The research proposes a blockchain-based solution tailored for C2C e-commerce in response to those limitations. This innovative approach, focusing on the underexplored area of blockchain application in C2C transactions, aims to enhance transparency and efficiency. The research uniquely combines Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis with practical applications, bridging the gap between theoretical exploration and real-world implications for the evolving C2C e-commerce landscape. The primary objectives of the research are to develop and validate a blockchain model for C2C e-commerce, assess its impact on market efficiency and transparency, and propose strategic recommendations for its implementation in real-world scenarios. The proposed blockchain solution directly addresses the requirement for a more transparent sales process, acknowledging the need for evolution.

This approach plays a significant role as an effective alternative to address inherent flaws in conventional database systems. The capabilities of blockchain technology, including automating transactions, real-time data tracking, and preventing unauthorized data manipulation (Li et al., 2019), position it as an optimal mechanism to enhance e-commerce data management and transaction processes. Integrating blockchain technology in e-commerce introduces the potential to construct a more secure and transparent environment for data management and transaction processes.

Despite blockchain's prominence over a decade, there is limited empirical evidence on the factors influencing technology adoption in the commercial e-commerce sector (Clohessy & Acton, 2019; Hughes et al., 2019; Kumar et al., 2021). Consumer skepticism towards embracing blockchain technology persists due to concerns and challenges in the e-commerce sector, such as fraud risks, price opacity, limited information transparency, constrained buyer-seller interactions, and misused data privacy (Felin & Lakhani, 2018). Nevertheless, blockchain offers solutions to these challenges within the sector through shared databases emphasizing attributes like immutability, transparency, and information traceability. Thus, blockchain can enable users to record and access accurate and detailed information.

While blockchain's features promise to overcome e-commerce issues, the industry's adoption of blockchain-based transactions still needs to grow. It is unfortunate as it can enhance transaction security, data recording, and efficiency. In this research context, a model-based approach is proposed to enhance efficiency and transparency within the environment of C2C e-commerce by utilizing blockchain technology as its foundation. Blockchain is identified as a potential solution to address complex challenges in data management and transaction processes through automated transaction mechanisms, real-time data tracking, and protection against unauthorized data manipulation. This approach aims to tackle burdensome commission costs, transparency deficits, and reliance on third-party validation and verification within the environment of C2C e-commerce. By reducing the role of intermediaries, blockchain technology opens the door to a fairer and more equitable environment for businesses and consumers. The approach applies the principles of distributed and tamper-proof databases, augmenting transparency and enabling access to verified information. Integrating blockchain technology enriched by a model-driven approach offers the opportunity to create a secure, efficient, and inclusive business environment, resulting in transformative shifts in business strategies and transactions within the evolving e-commerce ecosystem.

II. METHODS

The researchers adopt a systematic and multifaceted methodological approach to explore the application of blockchain technology in e-commerce. The initial step involves a systematic literature review, where the researchers gather relevant academic articles and case studies focusing on blockchain technology in the context of e-commerce. This comprehensive collection aims to cover all significant aspects and recent developments in the field. However, there may be shortcomings in this data collection method, such as potential bias in source selection or a lack of representation from diverse perspectives in the existing literature.

Following data collection, the researchers conduct a thematic analysis to identify key themes, such as security, transparency, user adoption, and market efficiency in the application of blockchain in e-commerce. This process assists the researchers in understanding how various aspects of blockchain interact within the e-commerce context. Nonetheless, this analysis may have limitations, including subjectivity in theme interpretation and the potential omission of important aspects underrepresented in the literature.

Subsequently, the researchers performed a SWOT analysis to evaluate the strengths, weaknesses, opportunities, and threats associated with the use of blockchain technology in e-commerce. This approach allows people to understand the potential impacts of blockchain technology comprehensively, identify areas for improvement, and strategize proactively by leveraging strengths and opportunities while mitigating weaknesses and threats (Niranjanamurthy et al., 2019). This analysis is crucial in understanding the potential and challenges of utilizing blockchain in this context. SWOT analysis is a comprehensive and crucial versatile tool for assessing new technologies like blockchain. It offers a balanced perspective by evaluating both internal capabilities and external opportunities or threats, thereby providing a holistic understanding of the potential impacts of technology implementation.

The SWOT analysis is carried out as shown in Figure 1. For strength, a distributed network on the blockchain is an essential value in the blockchain. It is a security solution for realizing data transparency between users (Li et al., 2019). Blockchain allows for establishing a decentralized network of relationships where each transaction is dependent on the one before it (Nikolakis et al., 2018; Vilkov & Tian, 2019). That way, applications with blockchain are a resilient ecosystem because it is difficult to find a system failure space in manipulating data changes by unauthorized parties who can secure data on public networks.

Next, for the weaknesses, the transition from centralized to distributed data recording requires rules that regulate interoperability for personal and public needs. Apart from that, blockchain technology eliminates the reliability of data storage required by most users, namely speed in processing data recording, which results in only a few types of data being suitable for storage on the blockchain network. It also means that gas fees charged for data recording can be minimized.

In threats, the implementation of blockchain has many pros and cons for many users, such as looking at the data security offered and having to pay the cost of recording data on the blockchain network, which depends on the complexity of the data stored on the blockchain network. Developing a blockchain network requires further development to reduce transaction costs, especially in recording data on the network.

Then, for opportunities, developing a blockchain-based e-commerce application requires expanding the scope of products being traded, not limited to digital products but also physical products. It is expected to make people aware of the importance of data transparency and security that can be realized from blockchain applications.

Based on insights gained from the literature review and SWOT analysis, the researchers formulate a conceptual framework. This framework aims to guide the application of blockchain technology in C2C e-commerce. While this framework is useful for providing direction, it may have limitations in addressing all the complexities and variables involved in real-world C2C e-commerce practices.

The final step involves proposing a specific blockchain model tailored for C2C E-Commerce. This model is based on the developed framework and aims to enhance efficiency and transparency in C2C e-commerce transactions. However, its shortcomings may include challenges in practical implementation and validation of the model in the real e-commerce environment.

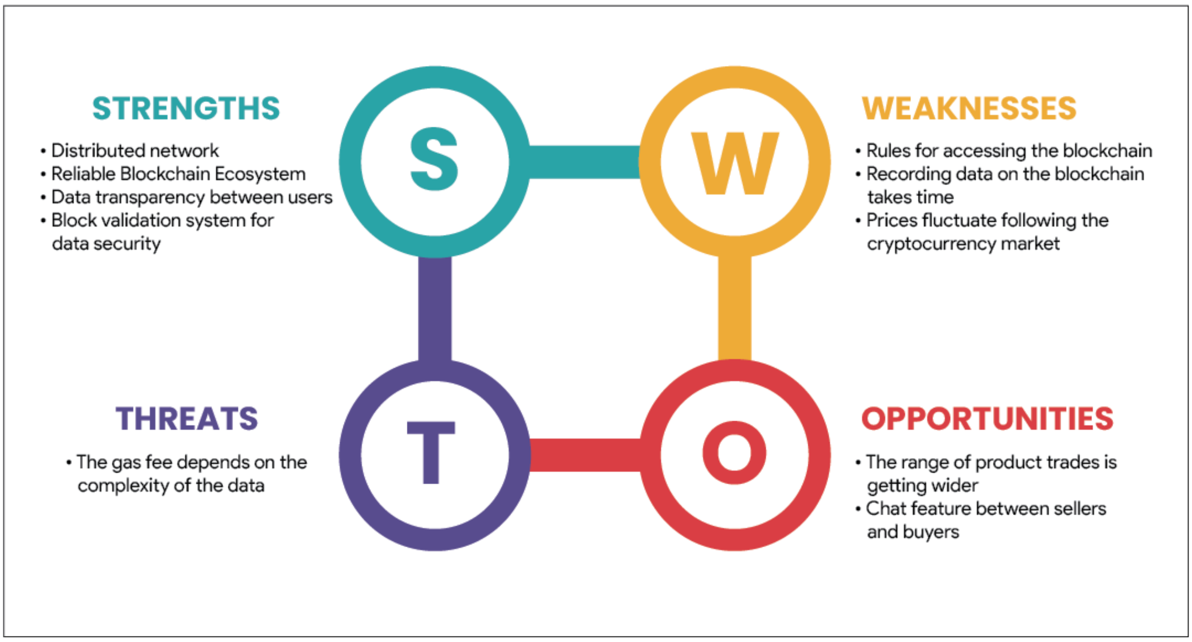

Figure 1 SWOT Analysis of Consumer-to-Consumer (C2C) Blockchain

In blockchain technology in C2C e-commerce, the researchers implement a rigorous data collection process involving a systematic search of databases and digital libraries. This search aims to gather relevant academic articles, industry reports, and case studies. Following data collection, a thematic analysis is undertaken to discern patterns and insights significant to the implementation of blockchain in C2C e-commerce. The analysis commences with an initial review of the materials for an overarching understanding of the content, leading to the identification of key themes such as security, transparency, user adoption, market efficiency, and regulatory considerations. These themes are found to emerge from recurring concepts and ideas related to the challenges, benefits, and practical applications of blockchain in the e-commerce domain. A careful analysis of each theme is conducted, and the findings are synthesized, culminating in the development of a conceptual framework. This thematic analysis proves instrumental not only in comprehending the current state of blockchain technology in e-commerce but also in pinpointing gaps and identifying potential areas for future research.

After looking at the SWOT analysis, a data collection process is implemented. Blockchain can be used in developing decentralized C2C e-commerce because it has benefits for future developments. Blockchain is structured data stored and spread throughout the network nodes that store information in size blocks. Each block has information about the hash value of previous blocks that are interconnected between one block and other blocks (Chowdhury et al., 2018). The first block on a blockchain is called the "Genesis block" (Badertscher et al., 2019).

As shown in Figure 2, blockchain data are linked from one block to another by using a hash transaction as a link. The data on a blockchain are also distributed. It means that every node on the network has a copy of the data on the blockchain. The absence of an administrator in the network allows each node to have the same role in verifying block data transactions by solving cryptographic puzzles on data block hashing. When a block is successfully verified and stored on the blockchain network, the information inside will be irreversible and can be accessed by all users on the network. Blockchain offers data transparency between unknown users to make transactions securely through cryptographic functions in data exchange. The blockchain should be used if it is appropriate and offers security and better potential to raise income and reduce costs (Niranjanamurthy et al., 2019). It can be implemented on the blockchain by using a Smart Contract, which is a link between transactions and data storage on the blockchain. A Smart Contract is a code of automatically executable or self-executable computer programs that form the basis of the blockchain to help automate various decision-making based on transactions or when a condition is met (Joshi & Kumar, 2020; Zheng et al., 2021).

The Smart Contract method is suitable for recording data and transactions (Zulkepli et al., 2023). Smart Contract calls will be executed through the browser while still communicating with the user's crypto wallet in every transaction interaction by the user. Therefore, integration between the browser and the user's wallet is needed with the help of the ethers.js library so that contract calls continue to run in both directions. Ethers.js, a user-friendly and lightweight library, is designed for efficient interaction with the Ethereum blockchain, offering essential features like wallet management and transaction signing, which are ideal for streamlined blockchain project development. Following is its implementation:

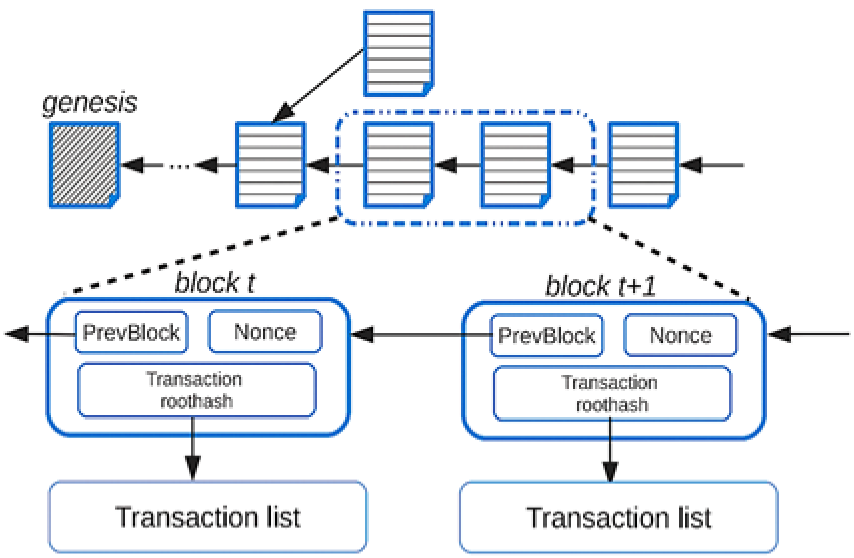

Figure 2 Blockchain Data Illustration (Dinh et al., 2018)

```
let provider = await detectEthereumProvider();
```

The code can detect whether there is a crypto wallet extension in the browser. If no wallet extension is found, the resulting output will be null. After that, what is done is to request the user's wallet to add the blockchain network configuration to the network list to enable the user's wallet to interact with the Smart Contract in the browser. With the help of the web3 library (Leal et al., 2020), it will request information about the blockchain network that has just been added, such as the Network ID, user account, and address of the user's wallet, which is integrated into the browser.

```
const myContract = new Contract(
        MyContract.networks[networkID].address,
        MyContract.abi,
        signer
);
```

The variable constructor of the contract is formed to carry out the Smart Contract functions that have been designed (Zou et al., 2021) and executed in the code previously. The contract will run side by side with the user's wallet data in the browser, where the data for each transaction that occurs will be recorded in the user's wallet as a crypto wallet activity history. Consequently, integrating these Smart Contract into the user's browser environment, where transaction data are recorded alongside wallet activity, aligns seamlessly with the use of Truffle.

Truffle is a widely adopted development and testing framework for Ethereum-based applications. It streamlines Smart Contract management and offers robust community support, making it a preferred choice for blockchain application development. Truffle is used to run Smart Contract on a blockchain network, which is a framework tool for development and testing in blockchain networks (Al-Madani et al., 2020) and running on Ethereum Virtual Machine (EVM). This tool makes developing Smart Contract on blockchain networks easier.

This illustration depicts a clear evolution in the efficiency and usability of the smart contract distribution process by implementing Truffle, a widely recognized development framework. Truffle's integration facilitates comprehensive testing procedures, enabling developers to assess the functionality and reliability of smart contracts within a controlled environment. This advancement simplifies identifying potential issues, enhances the accuracy of contract execution, and ultimately contributes to the seamless deployment of robust and secure smart contracts on the blockchain network (Zou et al., 2021). The visual representation in Figure 3 underscores the pivotal role of automation in simplifying the complex process of Smart Contract distribution, underscoring how technology such as Truffle empowers developers to create and deploy blockchain-based solutions with heightened confidence and effectiveness.

Smart Contract integration for transactions requires visualization on a blockchain-based e-commerce website. It is developed using the Models, Views, and Controllers (MVC) model approach. This model focuses on the functionality of the MVC website application (Wexler, 2019). Controllers are responsible for receiving user input, transmitting it to the model for processing, and ultimately presenting the results to users (Herron, 2020). On the other hand, models house the critical data management logic of the application. Views are the modules that render the processed data and present it to users in a comprehensible format. In developing applications on the MVC model, module refactoring is carried out based on the code's functionality to make it neater according to the objectives of each module to increase the efficiency of application development related to testing the program, which can be done in parts or modules.

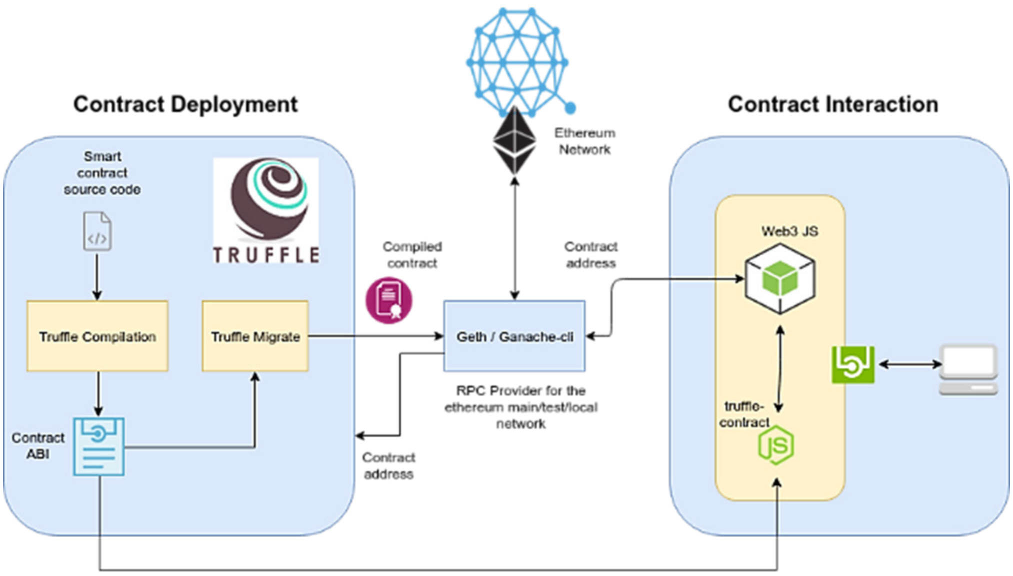

Figure 3 Distribution of Smart Contract with Truffle (Senthilnayaki et al., 2022)

III. RESULTS AND DISCUSSIONS

The proposed model for C2C e-commerce is elucidated in Figure 4, providing an illustrative depiction of the intricate interplay between sellers and buyers within this framework. This model serves as a conceptual blueprint, delineating the multifaceted roles assumed by each participant and elucidating the dynamic interactions that transpire within the ecosystem. Figure 4 offers a visual narrative articulating how the proposed C2C e-commerce model operates by highlighting the exchange of goods, services, and information between sellers and buyers.

This diagram articulates the distinct roles of sellers and buyers, showcasing their engagement in the transactional process and the reciprocal nature of their interactions. Furthermore, the model delves into the pivotal aspects of trust, verification, and transparency that underpin C2C e-commerce. The symbiotic relationship between sellers and buyers is underscored, emphasizing their shared responsibilities in ensuring the authenticity of transactions, fostering accountability, and upholding the integrity of the ecosystem.

By encapsulating the essence of this C2C e-commerce model in Figure 4, stakeholders are provided with a visual representation that enhances their understanding of the intricate dynamics at play. The model not only elucidates the roles and interactions of sellers and buyers but also serves as a foundation for strategic decision-making, process optimization, and implementing safeguards to mitigate potential challenges within the C2C e-commerce landscape. Through this visual exposition, the proposed model catalyzes a thriving environment of C2C e-commerce characterized by efficiency, reliability, and mutual benefit.

Figure 4 shows the importance of the C2C model in realizing interactions between sellers and buyers in a blockchain-based system. The user, as a seller, can take action to add products, publish products, confirm orders, and claim payment for these orders. In contrast, sellers can act as buyers to make product purchases, provide feedback on orders, and refund payment balances on orders. Each user's role goes in two directions with the help of a database management system and blockchain as a validator in every transaction between users involving crypto wallets as digital wallets that use cryptocurrency as the payment currency in the system.

A crypto wallet is a program container that manages cryptocurrency balance as a form of change from the inefficiencies of traditional currencies (Build N Build, n.d.). This wallet will keep the blockchain network ecosystem alive, consisting of public and private wallet addresses when conducting transactions. The private key in the wallet is used to sign transactions that occur. This private key cannot

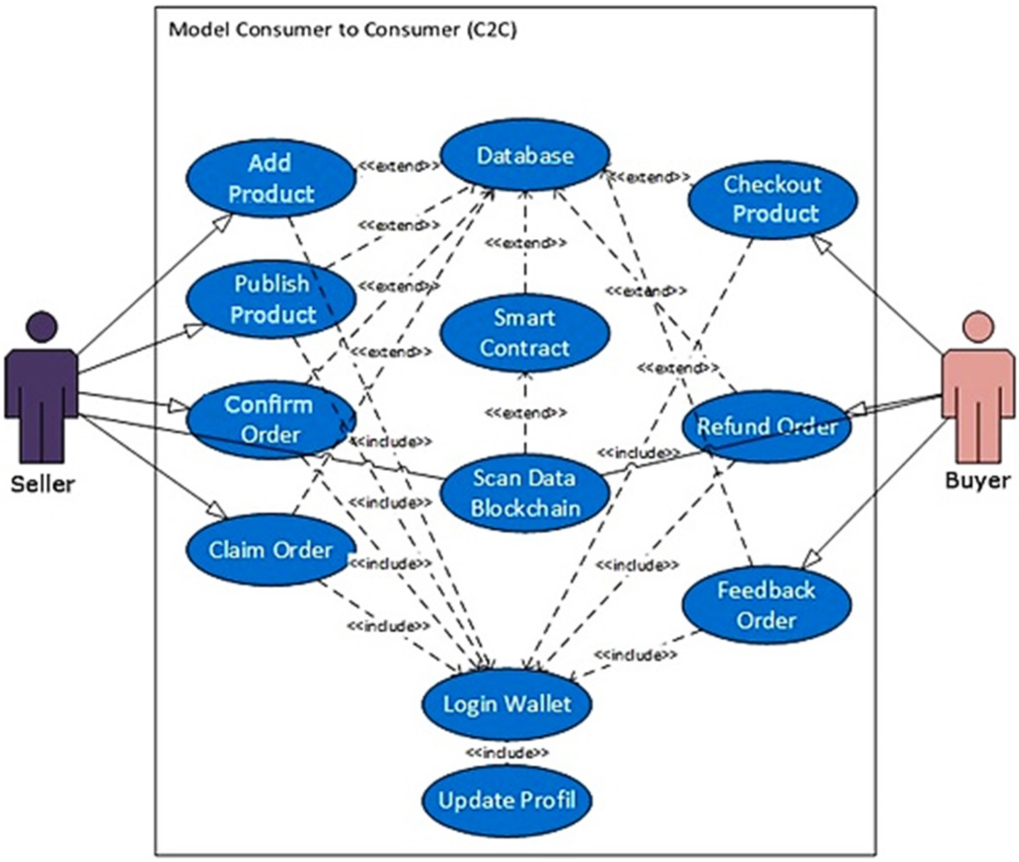

Figure 4 Blockchain of C2C E-Commerce Interaction Model

be seen in the wallet but can be mathematically contained in the user's wallet address. The private key in the wallet will be connected to the public key, which will be used to interact with other wallet addresses and sign transactions between wallets that are currently happening. Furthermore, it is essential to understand that the private key, which is linked to the public key for interactions with other wallet addresses and transaction signing, plays a crucial role. This seamless integration with Smart Contract, facilitated through communication between the crypto wallet user and the browser, is a pivotal aspect of recording information onto the blockchain.

Recording information in the blockchain is executed through seamless integration with Smart Contract, achieved via communication between the crypto wallet user and the browser. Each transaction necessitates the utilization of the ether.js library, effectively enabling the invocation of contracts to ensure bidirectional functionality. Smart Contract enables automated processes to control the execution of contracts that affect transaction costs (Dal Mas et al., 2020; Treiblmaier, 2018). This application of the Smart Contract methodology, which serves as a mechanism for data recording on the blockchain and enabling user interactions, is implemented within the framework of the C2C model approach.

Figure 5 shows how processed data are stored on the blockchain through interactions in Smart Contract created for C2C. The data stored come directly from sellers and buyers without intermediaries which store the data. All data are stored on the blockchain when the transaction process runs and triggers the smart contract to carry out verification of ongoing transactions. The instantiation of the Smart Contract is orchestrated through the Remix IDE, and meticulous testing is carried out within the confines of the local blockchain network before the contract's deployment onto the public blockchain network. Integrating tools such as Truffle, functioning as a comprehensive framework for developing and testing blockchain networks operating on the Ethereum Virtual Machine, contributes to the streamlined and efficient process of deploying and distributing Smart Contract onto the Binance Smart Chain Public Testnet network. Managing the Smart Contract compiler within Truffle and integrating the blockchain network with external libraries augments the operational capabilities of Truffle, thereby ensuring its seamless operation. It can be seen as follows.

```
truffle init
truffle compile
truffle migrate --reset -network bscTestnet
```

The Truffle function compiles and returns a JSON file containing the Smart Contract configuration, Application Binary Interface (ABI) code, and Bytecode contract program as a code interface containing function declarations along with parameters and the output of the contract function. Then, Truffle will deploy the smart contract in the project folder to the blockchain network with the network configuration name "bscTestnet" and generate the contract address from which it is successfully stored on the blockchain. Calling functions from contracts is assisted using an alternative web3 library, ethers.js. Ethers library provides complete and functional features to run on Web3 Provider. Its ability to use a custom provider allows the ethers library to communicate with the browser via RPC URLs and perform the contract functions to record data or payment transactions through smart contracts in two directions with the user's wallet.

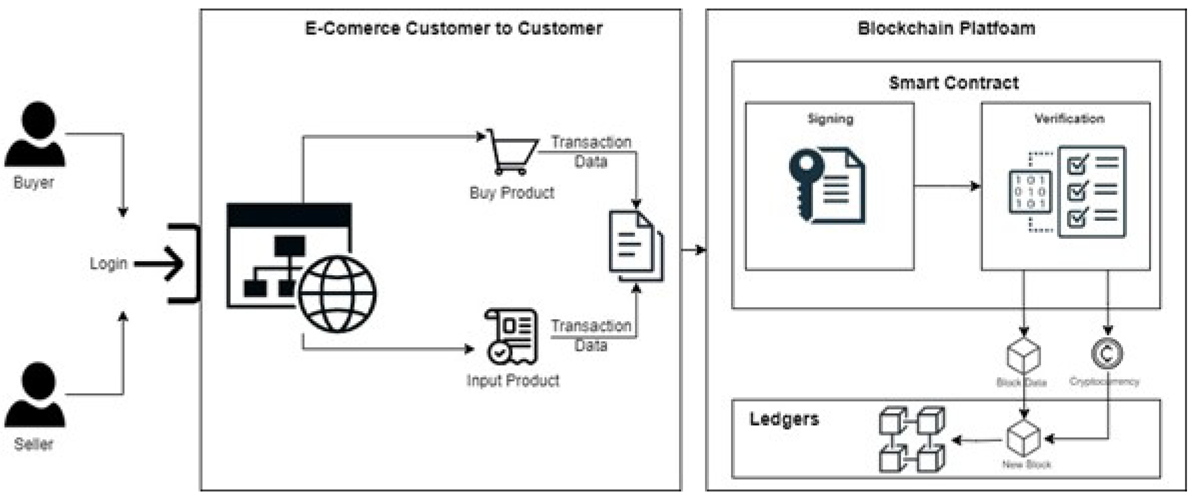

Figure 5 Data Recording Process on the Blockchain

The transaction process in Figure 6 is wholly carried out through Smart Contract without intermediaries validating the data. The validation is from the public context on the blockchain network. The data can be viewed via the Block Explorer site. It contains all transaction data on the blockchain network.

The block explorer shown in Figure 7 makes the mission of data transparency and decentralization of the blockchain network realized. Intermediaries in C2C e-commerce are no longer needed for data storage and cryptocurrency. It allows access to all user transaction data and distinguishes it from other data storage systems.

As e-commerce continues to develop, transaction costs can become an essential factor influencing businesspeople's decisions in choosing platforms for selling and shopping. Through comparison with other popular platforms in Table 1, it can be seen how blockchain-based e-commerce applications affect transaction costs in the sales and purchase process. Thus, the researchers can measure the extent of the potential efficiency offered by data transparency and security brought by blockchain technology.

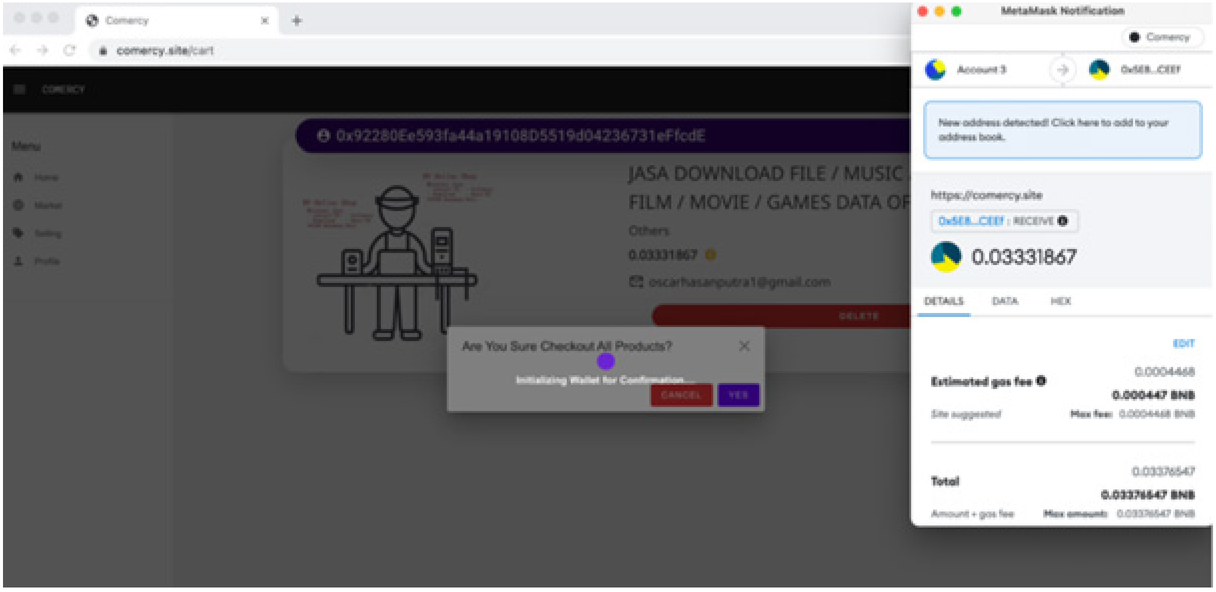

Figure 6 Interaction of Smart Contract with User's Wallet

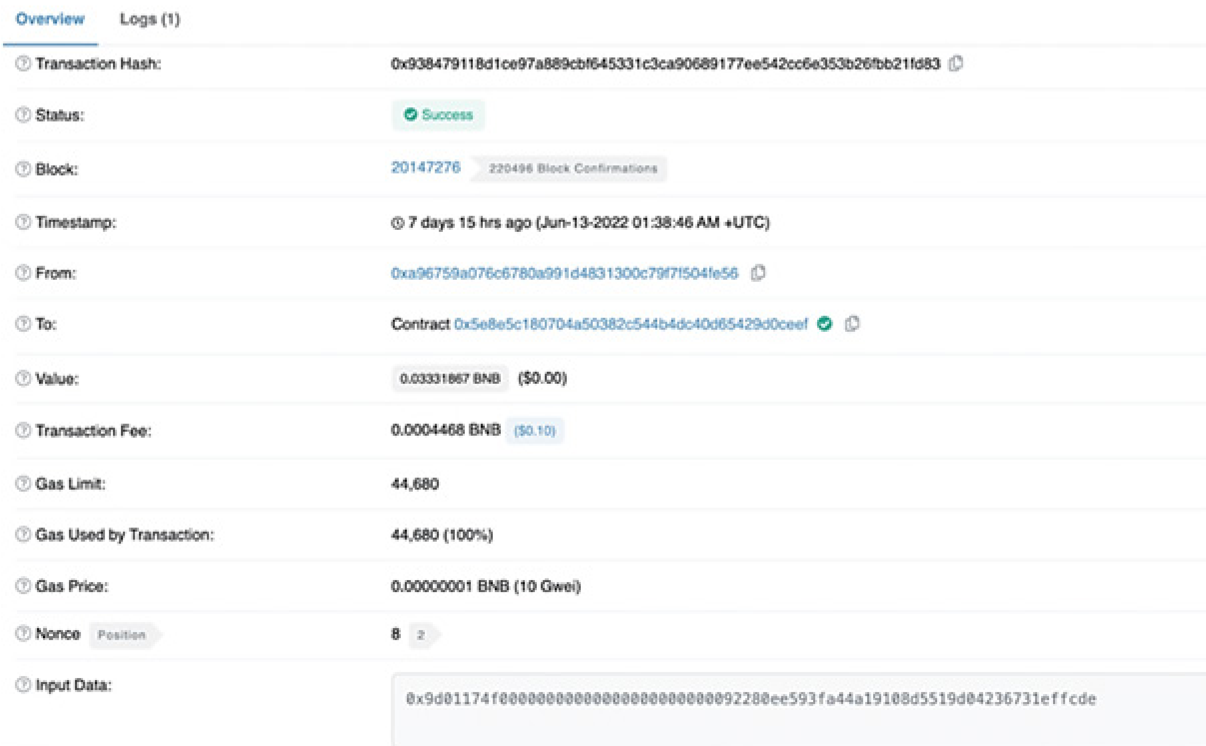

Figure 7 Recording Transaction Data on the Blockchain

Table 1 Comparative Transaction of Centralized E-commerce

Item	Consumer-to-Consumer (C2C) E-Commerce	Centralized E-Commerce 1	Centralized E-Commerce 2
Storage Type Data	Distributed	Centralized	Centralized
Regulation	-	Nasional	Nasional
Payment Method	Few Method	Multiple Methods	Multiple Methods
Type of Payment	Cryptocurrency	Digital Money/Cash Money	Digital Money/Cash Money
Payment Flow	Buyer → Smart Contract → Seller	Buyer → Courier/ Agency → Seller	Buyer → Courier/ Agency → Seller
Data Transparency	Yes	No	No
Sales Fees	≈ 0.00023BNB (Rp807.55)	2.5%–3%	4%–7.5%
Product Registration Fee	>Rp1.000/product	Rp0/product	Rp0/product

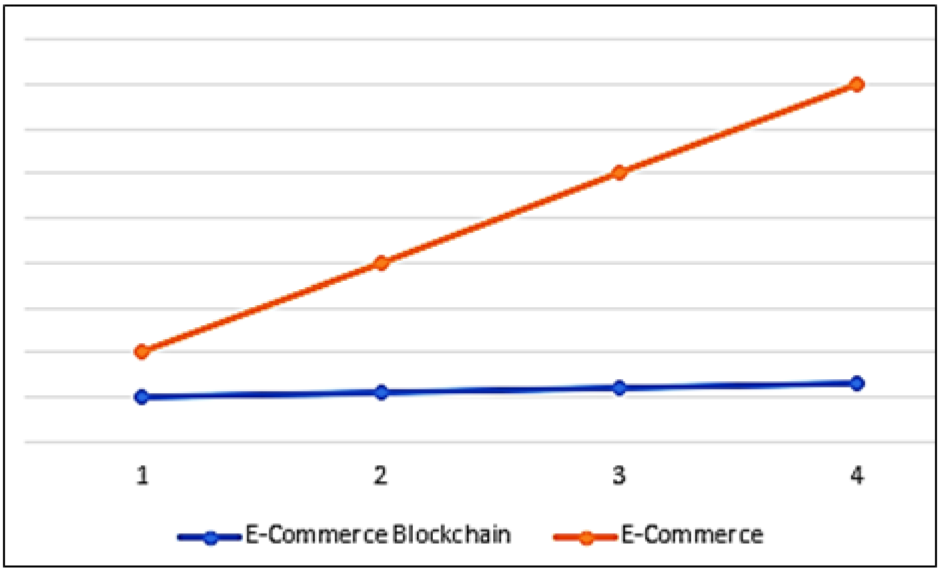

Figure 8 Illustration of Cost Comparison

Table 1 shows the costs of selling each product in e-commerce. From each fee charged to the seller, it is found that service fees from blockchain-based e-commerce platforms tend to be constant per sales transaction because they calculate the storage costs even though there is an initial fee for each product registered on the blockchain. Meanwhile, other e-commerce companies charge a service fee depending on the product's price. It can be concluded that blockchain-based C2C e-commerce applies initial costs, and subsequent costs are constant regardless of the product's price. Meanwhile, in other e-commerce, costs will increase with the price of the goods offered.

It can be seen in Figure 8 that the implementation of blockchain-based transactions is efficient, service costs do not depend on product prices, and the number of sales increases. Recording transaction fees, which tend to be constant in cryptocurrencies, but fluctuating cryptocurrency prices can cause transaction fees to increase or decrease, which are charged to sellers from blockchain-based e-commerce platforms. The costs incurred are data recording costs to secure data on the public Testnet blockchain network.

Data transparency and security efficiency in blockchain-based e-commerce can be measured in transaction recording costs. Blockchain technology allows for recording transactions that cannot be manipulated and can be verified with accuracy. It can potentially reduce the risk of fraud and costs for auditing transactions. In addition, better security can also avoid costs that may occur due to data security breaches.

In this comparison, it can analyze how transaction costs in blockchain e-commerce compare with transaction costs in other e-commerce. Apart from transaction costs, it can also evaluate to what extent each platform offers ease of use, level of security, and transparency. It can provide a clearer view of how practical blockchain-based e-commerce applications are in optimizing transaction costs and providing a more secure and transparent environment.

While businesses and policymakers can benefit from effective blockchain integration in e-commerce, it is crucial to acknowledge that the challenges posed by fluctuating crypto prices and changing gas fees based on network density can impact the overall cost efficiency of transactions. Therefore, alongside prioritizing data transparency and security, stakeholders should consider how the dynamics of crypto price fluctuations and gas fees may influence transaction fees. In light of these challenges, businesses should invest in stakeholder education and training for blockchain integration, focusing on data security and regulatory compliance. Simultaneously, policymakers can contribute by establishing supportive regulations, offering incentives through tax breaks, and fostering collaborations with industry experts. A collective emphasis on user-friendly interfaces is essential for widespread adoption and ensuring a seamless user experience.

IV. CONCLUSIONS

The research results show that the transformative capabilities of blockchain technology resonate throughout the foundations of modern commerce. The potential to enhance transparency, streamline automation, and fortify the bedrock of security in a realm laden with transactions and data management users in a new era within the vast landscape of e-commerce. This epoch has been profoundly shaped by the sweeping influence of the Internet. Blockchain's quintessential attributes, most notably its intrinsic capacity for transparent transactions and the dynamic functionality of Smart Contract, stand as formidable assets that can adequately navigate and alleviate the intricate challenges entrenched in the traditional fabric of e-commerce. Moreover, integrating blockchain with the C2C model can create a fairer e-commerce environment with improved information access. However, challenges like fraud risks and cryptocurrency concerns hinder its adoption.

In summary, the fusion of blockchain and e-commerce holds the potential to reshape transactions and relationships, promising a more transparent and efficient future for global commerce. The research delves into the insights of blockchain's impact on C2C e-commerce, emphasizing its contributions to transparency, security, and efficiency. While acknowledging the research's focus on specific aspects as a limitation, the findings provide a strategic roadmap for businesses and policymakers. The call for future research to broaden its scope echoes the transformative possibilities at the dynamic intersection of technology and commerce.

REFERENCES

Al-Madani, A. M., Gaikwad, A. T., Mahale, V., & Ahmed, Z. A. T. (2020). Decentralized e-voting system based on Smart Contract by using blockchain technology. In *2020 International Conference on Smart Innovations in Design, Environment, Management, Planning and Computing (ICSIDEMPC)* (pp. 176–180). IEEE. https://doi.org/10.1109/ICSIDEMPC49020.2020.9299581

Badertscher, C., Gaži, P., Kiayias, A., Russell, A., & Zikas, V. (2019). *Ouroboros chronos: Permissionless clock synchronization via proof-of-stake*. Cryptology Eprint Archive. https://eprint.iacr.org/2019/838

Build N Build. (n.d.). *BNB chain: An ecosystem of blockchains.* https://docs.bnbchain.org/docs/overview

Bulsara, H. P., & Vaghela, P. S. (2020). Blockchain technology for e-commerce industry. *International Journal of Advanced Science and Technology*, *29*(5), 3793–3798.

Chowdhury, M. J. M., Colman, A., Kabir, M. A., Han, J., & Sarda, P. (2018). Blockchain versus database: A critical analysis. In *17th IEEE International Conference on Trust, Security and Privacy in Computing and Communications/ 12th IEEE International Conference on Big Data Science And Engineering (TrustCom/BigDataSE)* (pp. 1348–1353). IEEE. https://doi.org/10.1109/TrustCom/BigDataSE.2018.00186

Clohessy, T., & Acton, T. (2019). Investigating the influence of organizational factors on blockchain adoption: An innovation theory perspective. *Industrial Management & Data Systems*, *119*(7), 1457–1491. https://doi.org/10.1108/IMDS-08-2018-0365

Dal Mas, F., Dicuonzo, G., Massaro, M., & Dell'Atti, V. (2020). Smart Contracts to enable sustainable business models. A case study. *Management Decision*, *58*(8), 1601–1619. https://doi.org/10.1108/MD-09-2019-1266

Dinh, T. T. A., Liu, R., Zhang, M., Chen, G., Ooi, B. C., & Wang, J. (2018). Untangling blockchain: A data processing view of blockchain systems. *IEEE Transactions on Knowledge and Data Engineering*, *30*(7), 1366–1385. https://doi.org/10.1109/TKDE.2017.2781227

Felin, T., & Lakhani, K. (2018). What problems will you solve with blockchain? *MIT Sloan Management Review*, *60*(1), 32–38.

Herron, D. (2020). *Node. js web development: Server-side web development made easy with Node 14 using practical examples*. Packt Publishing Ltd.

Hughes, L., Dwivedi, Y. K., Misra, S. K., Rana, N. P., Raghavan, V., & Akella, V. (2019). Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda. *International Journal of Information Management*, *49*, 114–129. https://doi.org/10.1016/j.ijinfomgt.2019.02.005

Ismanto, L., Ar, H. S., Fajar, A. N., Sfenrianto, & Bachtiar, S. (2019). Blockchain as e-commerce platform in Indonesia. *Journal of Physics: Conference Series*, *1179*, 1–6. https://doi.org/10.1088/1742-6596/1179/1/012114

Joshi, P., & Kumar, A. (2020). A novel framework for decentralized C2C e-commerce using smart contract. In *11th International Conference on Computing, Communication and Networking Technologies, (ICCCNT)* (pp. 1–5). IEEE. https://doi.org/10.1109/ICCCNT49239.2020.9225377

Kumar, S., Lim, W. M., Pandey, N., & Westland, J. C. (2021). 20 years of electronic commerce research. *Electronic Commerce Research, 21*, 1–40. https://doi.org/10.1007/s10660-021-09464-1

Leal, F., Chis, A. E., & González–Vélez, H. (2020). Performance evaluation of private Ethereum networks. *SN Computer Science*, *1*(5). https://doi.org/10.1007/s42979-020-00289-7

Li, M., Shen, L., & Huang, G. Q. (2019). Blockchain-enabled workflow operating system for logistics resources sharing in e-commerce logistics real estate service. *Computers and Industrial Engineering*, *135*, 950–969. https://doi.org/10.1016/j.cie.2019.07.003

Miraz, M. H., & Ali, M. (2018). Applications of blockchain technology beyond cryptocurrency. *Annals of Emerging Technologies in Computing (AETiC)*, *2*(1), 1–6. https://doi.org/10.33166/AETiC.2018.01.001

Nikolakis, W., John, L., & Krishnan, H. (2018). How blockchain can shape sustainable global value chains: An Evidence, Verifiability, and Enforceability (EVE) framework. *Sustainability*, *10*(11), 1–16. https://doi.org/10.3390/su10113926

Niranjanamurthy, M., Nithya, B. N., & Jagannatha, S. (2019). Analysis of blockchain technology: Pros, cons and SWOT. *Cluster Computing*, *22*, 14743–14757. https://doi.org/10.1007/s10586-018-2387-5

Senthilnayaki, B., Mahalakshmi, G., Narashiman, D., Mahendran, E., Premanandh, M., & Sairamesh, L. (2022). A secure e-governance system using blockchain techniques. *Advances in Parallel Computing, 41,* 443–448. https://doi.org/10.3233/APC220062

Shorman, S., Allaymoun, M., & Hamid, O. (2019). Developing the e-commerce model a consumer to consumer using blockchain network technique. *International Journal of Managing Information Technology (IJMIT)*, *11*(2), 55–64. https://doi.org/10.5121/ijmit.2019.11204

Treiblmaier, H. (2018). The impact of the blockchain on the supply chain: A theory-based research framework and a call for action. *Supply Chain Management*, *23*(6), 545–559. https://doi.org/10.1108/SCM-01-2018-0029

Vilkov, A., & Tian, G. (2019). Blockchain as a solution to the problem of illegal timber trade between Russia and China: SWOT analysis. *International Forestry Review*, *21*(3), 385–400. https://doi.org/10.1505/146554819827293231

Wexler, J. (2019). *Get programming with Node. js*. Simon and Schuster.

Zheng, G., Gao, L., Huang, L., & Guan, J. (2021). *Ethereum Smart Contract development in solidity*. Springer Singapore. https://doi.org/10.1007/978-981-15-6218-1

Zhu, X., & Wang, D. (2019). Research on blockchain application for e-commerce, finance and energy. In *IOP Conference Series: Earth and Environmental Science*. IOP Publishing Ltd. https://doi.org/10.1088/1755-1315/252/4/042126

Zou, W., Lo, D., Kochhar, P. S., Le, X. B. D., Xia, X., Feng, Y., Chen, Z., & Xu, B. (2021). Smart Contract development: Challenges and opportunities. *IEEE Transactions on Software Engineering*, *47*(10), 2084–2106. https://doi.org/10.1109/TSE.2019.2942301

Zulkepli, M. I. S., Mohamad, M. T., & Azzuhri, S. R. (2023). Leveraging blockchain-based Smart Contract in Islamic financial institutions: Issue and relevant solution. *International Journal of Islamic Economics and Finance Research*, *6*(1), 18–28. https://doi.org/10.53840/ijiefer96