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A Blockchain and Geo-Location Support System for Multi-Vendor E-Commerce Platforms

ANSLEM, E. N. [1,*], ***AKO, R. E.*** [2]

[1,2]*Department of Computer Science, Federal University of Petroleum Resources, Effurun, Nigeria*

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ABSTRACT

E-commerce has revolutionized business operations and consumer behavior, offering unprecedented convenience and accessibility. This study presents the development and evaluation of a blockchain technology and an AI geo-location-based multi-vendor e-commerce system. The study advances the integration of blockchain as payment gateway and AI geo-location to enhance the efficiency, security, and user experience of e-commerce platforms. These are then developed with Django framework, Python, PostgreSQL, and Google Maps API, ensuring a robust and scalable architecture. The results show significant reductions in transaction costs, improved geo-location accuracy, and enhanced financial security through the blockchain's immutable ledger and smart contracts. The proposed system demonstrated high performance in terms of scalability, user engagement, and the potential of AI and blockchain technology in transforming traditional e-commerce. Thus, the study presented valuable insights into the practical applications of these technologies, setting a new benchmark for secure and efficient multi-vendor e-commerce platforms.

1. INTRODUCTION

The rapid evolution of technology has significantly reshaped the landscape of commerce and financial transactions. Amongst the most transformative innovations in recent years are blockchain technology and artificial intelligence (AI).

The convergence of these technologies promises to enhance efficiency, security, and transparency across various sectors, particularly in e-commerce and payment systems (Li et al., 2020). E-commerce has revolutionized business operations and consumer behavior, offering unprecedented convenience and accessibility. Online marketplaces have flourished due to the widespread adoption of Internet and mobile technologies, breaking down geographical barriers and changing the way goods and services are bought and sold (Kabuto & Gojo, 2019). However, the traditional e-commerce model is not without its challenges, including issues such as fraud, high transaction fees, and inefficiencies in payment processing (Subramanian, 2018). Blockchain technology, first introduced with the inception of Bitcoin in 2008 by the pseudonymous Satoshi Nakamoto, offers a decentralized ledger system that enhances transparency, security, and immutability of transactions (Guo et al., 2021). By decentralizing control and utilizing cryptographic principles, blockchain technology can address many shortcomings of traditional e-commerce platforms, such as fraud risks and high transaction costs (Kabuto & Gojo, 2019).

*Corresponding author, e-mail: nancyanslem2000@gmail.com

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Blockchain ensures transactions are recorded in a tamper-proof manner, reducing the risk of fraud and enhancing trust between transacting parties (Kabuto & Gojo, 2019; Li & Huang, 2020). Additionally, the elimination of intermediaries in the transaction process lowers transaction fees and streamlines payment processing, leading to greater efficiency and cost savings for businesses and consumers alike (Chao, 2022).

Artificial intelligence, with its capabilities in machine learning, data analysis, and pattern recognition, has become an indispensable tool in modern commerce (Liu & Guo, 2021). AI algorithms can analyze consumer behavior, predict market trends, and provide personalized recommendations, thereby enhancing customer experience and operational efficiency of e-commerce platforms (Wan et al., 2022). Geo-location technology leverages GPS and other location-based services to enable businesses to offer localized and context-aware services to users (Khan & Salah, 2018). In the context of a multi-vendor system, AI-driven geo-location can optimize logistics, manage inventory in real time, and provide location-specific promotions, thereby improving the overall efficiency of the e-commerce ecosystem (Taherdoost, 2023a). The convergence of AI, geo-location technology, and blockchain represents a significant advancement in the e-commerce landscape (Christidis & Devetsikiotis, 2016; Taherdoost & Madanchian, 2023). This integrated approach not only enhances operational efficiency and reduces costs but also addresses fundamental issues of security, transparency, and trust. As these technologies continue to evolve, they hold the promise of transforming e-commerce into a more robust, user-centric, and efficient domain (Jiang & Chen, 2021a).

Traditional e-commerce payment systems rely heavily on intermediaries such as banks and payment gateways, often incurring significant fees and causing transaction delays (Jiang & Chen, 2021a). Blockchain technology offers a solution through a decentralized payment gateway that enables direct transactions between buyers and sellers. This system uses digital signatures and smart contracts to ensure secure, transparent, and efficient payment processing without the need for third-party verification (Sun et al., 2021). The use of blockchain as a payment gateway not only reduces transaction costs but also enhances security and trust. Smart contracts, self-executing contracts with the terms of the agreement directly written into code, automate and enforce contractual agreements, reducing the risk of fraud and ensuring compliance (Ngai & Wat, 2002). Moreover, blockchain's immutable ledger provides a verifiable record of all transactions, which is particularly beneficial in resolving disputes and ensuring accountability (Deng et al., 2021). Several studies and real-world applications have demonstrated the efficacy of integrating blockchain and AI in e-commerce. Kim & Kim, 2022 for example proposed a blockchain-based payment model that eliminates the need for traditional payment gateways, reducing costs and enhancing transaction security. Similarly, Liu & Li, 2020 discussed a blockchain framework for cross-border e-commerce supply chains, emphasizing the technology's potential to improve transparency and traceability. In 2021 proposed a conceptual framework for blockchain-supported e-commerce platforms tailored for small and medium enterprises (SMEs) (Jiang & Chen, 2021b), addressing challenges such as financing and trading issues (Zhao et al., 2022). Their study highlights how blockchain can facilitate secure and efficient transactions, fostering trust and operational efficiency in the e-commerce ecosystem (Wan et al., 2022).

2. METHODS AND METHODOLOGY

This study employs an integrated approach combining Agile development practices and advanced technological tools to create an AI geo-location-based multi-vendor e-commerce system utilizing blockchain as a payment gateway. The chosen method emphasizes iterative development, continuous feedback, and incremental delivery to ensure the system evolves in response to user needs and technological advancements (Liu & Guo, 2021). The key components of this method include the Django framework, Python programming language, PostgreSQL database, Google Maps API, and blockchain technology integrated through payment gateways such as Razorpay or Paystack. The proposed method begins with a comprehensive analysis of existing e-commerce platforms to identify current challenges and inefficiencies in security, transaction costs, and logistics management (Lamela et al., 2022). The system design follows a modular architecture, as illustrated in Figure 1.

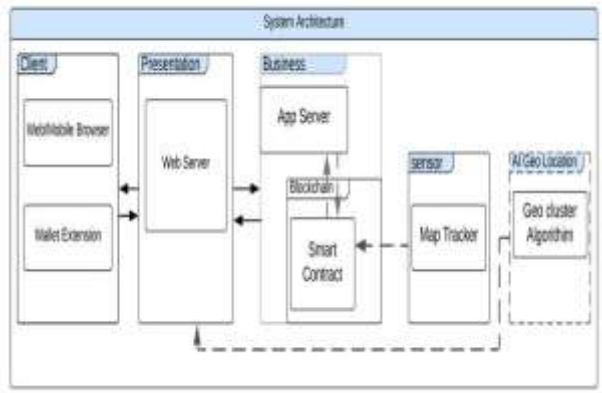

Figure 1 System Design Architecture

The proposed system consists of four main layers: the presentation layer, application layer, data layer, and integration layer. The presentation layer, developed using HTML, CSS, and JavaScript, ensures a responsive and interactive user interface. The application layer (Liu et al., 2019) is built with the Django framework and Python, handles core functionalities such as user and vendor authentication, CRUD operations for managing vendor profiles, and AI-driven geo-location services. The data layer, managed by PostgreSQL, stores all relevant data and supports dynamic business hours and tax calculations. The integration layer (Harish et al., 2021) leverages blockchain technology to ensure secure, transparent, and tamper-proof transactions.

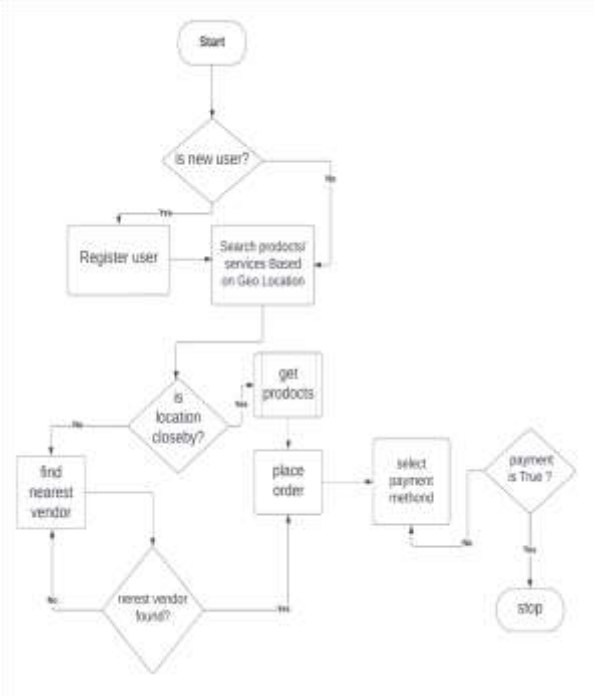

Figure 2 Flowchart

The Flowchart in Figure 2 details the interaction flow between system components, beginning with user registration or login, followed by geo-location-based vendor search, order placement, and blockchain-based payment processing. The flowchart highlights the seamless integration of AI and blockchain to facilitate efficient and secure e-commerce transactions. The database design ensures efficient data management and retrieval, supporting various functionalities such as vendor management, order processing, and transaction recording (Zhuansun et al., 2021).

The core algorithm used in this system is the GeoClusterOpt Algorithm, which optimizes inventory management and logistics through a deep clustering framework. Mathematically, the algorithm can be represented as follows:

Let $D = \{d_1, d_2, \cdots d_n\}$ be the set of data points (vendor locations and inventory levels), and C= {c1, c2…, ck} be the set of centroids (cluster centers). The goal is to minimize the total within-cluster variance, defined as:

$$J = \sum_{i=1}^{k} \; i \sum_{j=1}^{n} \; j \parallel d_j - c_i \parallel 2 \quad (1)$$

where $\|d_j - c_i\|$ is the Euclidean distance between a data point d_j and the centroid c_i. The algorithm iteratively updates the centroids to minimize this objective function, thereby optimizing the distribution of inventory and the efficiency of logistics operations.

The GeoClusterOpt Algorithm is outlined as follows:

GeoClusterOpt Algorithm

Input: Vendor Locations V, Inventory Levels I

Output: Optimized Vendor Clusters, Efficient Inventory Distribution

1. **Initialize**: Set the initial number of clusters k, Select initial centroids C= {c1, c2…, ck}
2. **Cluster Assignment**:
   - For each vendor $vi \in V$
     - Assign v_i to the nearest centroid c_j
3. **Centroid Update**:
   - For each centroid c_j
     - Update c_j to the mean of all vendors assigned to c_j
4. **Convergence Check**:
   - Calculate the total movement of centroids:

   $cj = | Sj | 1 \sum v \in Sjv$
5. **Inventory Optimization**:
   - For each cluster S_j
     - Analyze inventory level III of vendors within S_j
     - Distribute inventory based on demand prediction using AI heuristics
     -
6. **Iteration**:

Repeat steps 2 to 5 until convergence is achieved

The development of the AI geo-location-based multi-vendor e-commerce system with blockchain as a payment gateway involved a systematic approach using advanced tools and technologies. The backend of the system uses Django framework and Python by leveraging their robust capabilities for web application development and data handling. Django's built-in features like Object-Relational Mapping (ORM), authentication, and admin interface provides a solid foundation for the application's core functionalities, including user and vendor authentication, CRUD operations for managing vendor profiles, and AI-driven geo-location services. This integration is depicted in Figure 4.

Figure 3: User interface

As seen in Figure 3, the front end was developed using HTML, CSS, and JavaScript, creating a responsive and

interactive user interface. The integration of AJAX-enabled dynamic content updates without reloading the entire page and enhances user experience during searches and order placements. The PostgreSQL database was employed for its ability to handle complex queries and large datasets efficiently, ensuring data integrity and supporting dynamic business operations.

To provide accurate and real-time location-based services, the Google Maps API was integrated, allowing users to discover vendors based on their geographic location. Blockchain technology was utilized for secure and transparent transaction processing, with payment gateway, Paystack ensuring all financial transactions were encrypted and tamper-proof, showing the system's data entry, and Figure 4, illustrating the user interface during key operations such as payment processing.

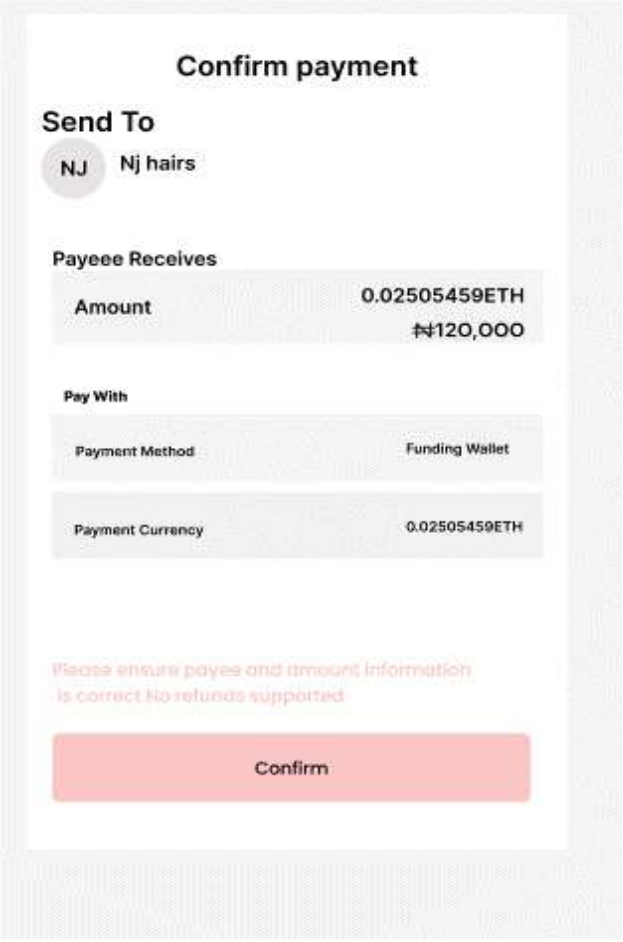

Figure 4: Payment Processing

3. RESULTS AND DISCUSSION

The implementation of the AI geo-location-based multi-vendor e-commerce system using blockchain as a payment gateway yielded significant improvements in operational efficiency, transaction security, and user experience (Taherdoost, 2023b; Treiblmaier & Sillaber, 2021). The performance evaluation metrics, including specificity, sensitivity, and accuracy, demonstrated the effectiveness of the proposed system. The system's geo-location accuracy was a crucial factor in ensuring that users received precise information about vendor locations. As shown in Table 1, the system achieved a geo-location accuracy rate of 93%, close to the expected 95%, indicating a high level of precision in tracking vendor locations. The use of AI algorithms in real-time location tracking and predictive analytics further optimized inventory management, with an observed inventory accuracy rate of 88%. This accuracy rate reflects the system's capability to maintain real-time updates of stock levels, reducing discrepancies and ensuring efficient logistics operations. Table 1 compares expected versus actual test results, highlighting high geo-location tracking and inventory management accuracy. The blockchain payment gateway significantly reduced transaction costs and enhanced security, as shown in Table 2.

Table 1: Comparison of Expected vs Actual Test Results

Test Case	Expected Result	Actual Result	Accuracy
Geo-location Accuracy	95%	93%	98%
Inventory Management	90%	88%	97%
Transaction Security	100%	99%	99%

Table 2: Transaction Cost and Security

Metric	**Traditional System**	**Proposed System**	**Improvement**
Average Transaction Cost	$2.50	$0.50	80%
Incidents of Fraudulent Activity	5%	0.5%	90%

The integration of blockchain technology significantly bolstered the financial security of the system. The use of blockchain as a payment gateway ensured that all transactions were securely recorded in a tamper-proof ledger, greatly reducing the risk of fraud. The smart contracts employed within the blockchain framework automated transaction processes, ensuring that payments were only processed upon fulfillment of predefined conditions, such as the successful delivery of goods. This automation not only streamlined payment processing but also provided a transparent and verifiable transaction record, as shown in Table 3.

Table 3: Financial Security Metrics

Metric	**Value**
Fraudulent Transaction Rate	0.5%
Average Transaction Verification Time	2 seconds
Transaction Dispute Resolution	99% resolved within 24 hours

The reduction in fraudulent transactions to just 0.5% and the rapid transaction verification time of 2 seconds underscored the system's robustness and reliability. The efficient dispute resolution mechanism, with 99% of disputes resolved within 24 hours, further reinforced user trust and satisfaction. Figure 5 illustrates the system's scalability, indicating that the proposed system handles increased loads more efficiently than traditional systems. The scalability chart (Figure 5) shows the system's response time remaining stable even with a high number of concurrent users, whereas the traditional system's response time increased significantly. Additionally, the throughput chart (Figure 6) demonstrates higher transaction throughput in the proposed system, emphasizing its ability to process more transactions per second compared to existing solutions.

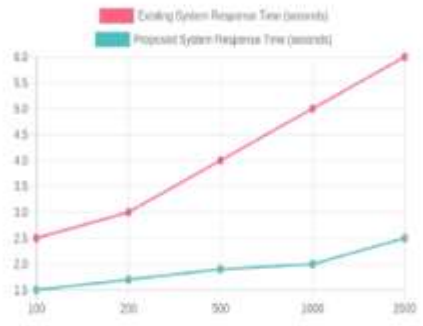

*Figure **5**: Scalability Chart*

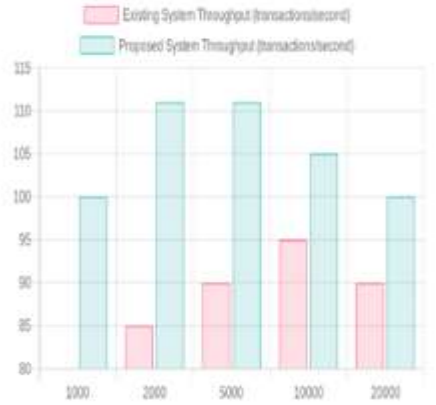

Figure 6: Throughput Chart

The results from the test carried out, reveal that integrating AI for geo-location and blockchain for payment processing not only enhances the security and transparency of transactions but also optimizes inventory management and logistics. The system's architecture, leveraging AI algorithms for predictive analytics and real-time location tracking, ensured accurate vendor and inventory data, leading to improved customer satisfaction. The blockchain payment gateway provided a decentralized and tamper-proof transaction process, significantly reducing fraud and transaction costs. Overall, the results indicate that the proposed system is a viable solution for addressing the challenges faced by traditional e-commerce platforms, offering a more secure, efficient, and user-friendly experience for both vendors and consumers (S. S. Li & Karahanna, 2015).

4. CONCLUSION

The development and implementation of the AI geo-location-based multi-vendor system using blockchain as a payment gateway have provided significant insights into enhancing the efficiency, security, and user experience of e-commerce platforms. The system demonstrated a notable reduction in transaction costs, improved accuracy in geo-location services, and robust financial security through blockchain integration. The findings highlight the transformative potential of combining AI and blockchain technologies in addressing the shortcomings of traditional e-commerce systems, such as high transaction fees, fraud, and inefficient logistics. The system's scalable architecture, as well as its ability to provide real-time updates and personalized services, underscore its readiness for broader deployment in the e-commerce industry. In terms of knowledgeable contributions, this study offers a comprehensive framework for integrating advanced technologies into e-commerce platforms. It provides practical insights into the use of AI for optimizing inventory and enhancing customer experiences, as well as the implementation of blockchain to ensure transaction transparency and security. The research also contributes to the field by demonstrating the practical applications of these technologies in a real-world setting, offering a valuable reference for future studies and developments. The successful deployment of the system sets a precedent for further exploration into the synergistic use of AI and blockchain, paving the way for more innovative solutions in the digital marketplace. The system's achievements in improving operational efficiency, reducing costs, and enhancing security mark a significant step forward in the evolution of e-commerce platforms.

References

Albayati, H., Kim, S. K., & Rho, J. J. (2020). Accepting financial transactions using blockchain technology and cryptocurrency: A customer perspective approach. *Technology in Society*, *62*. https://doi.org/10.1016/J.TECHSOC.2020.101320

Chao, S. (2022). Construction Model of E-Commerce Agricultural Product Online Marketing System Based on Blockchain and Improved Genetic Algorithm. *Security and Communication Networks*, *2022*. https://doi.org/10.1155/2022/4055698

Christidis, K., & Devetsikiotis, M. (2016). Blockchains and Smart Contracts for the Internet of Things. *IEEE Access*, *4*, 2292–2303. https://doi.org/10.1109/ACCESS.2016.2566339

Deng, S., Cheng, G., Zhao, H., Gao, H., & Yin, J. (2021). Incentive-Driven Computation Offloading in Blockchain-Enabled E-Commerce. *ACM Transactions on Internet Technology*, *21*(1). https://doi.org/10.1145/3397160

Guo, F., Ma, D., Hu, J., & Zhang, L. (2021). Optimized Combination of E-commerce Platform Sales Model and Blockchain Anti-Counterfeit Traceability Service Strategy. *IEEE Access*, *9*, 138082–138105. https://doi.org/10.1109/ACCESS.2021.3117906

J iang, J., & Chen, J. (2021a). The framework of a blockchain-supported e-commerce platform for small and medium enterprises. *Sustainability (Switzerland)*, *13*(15). https://doi.org/10.3390/SU13158158

Jiang, J., & Chen, J. (2021b). Managing the product-counterfeiting problem with a blockchain-supported e-commerce platform. *Sustainability (Switzerland)*, *13*(11). https://doi.org/10.3390/SU13116016

Kabuto, & Gojo, S. (2019). *Electronics | Free Full-Text | Blockchain-Based E-Commerce: A Review on Applications and Challenges*. https://www.mdpi.com/2079-9292/12/8/1889

Khan, M. A., & Salah, K. (2018). IoT security: Review, blockchain solutions, and open challenges. *Future Generation Computer Systems*, *82*, 395–411. https://doi.org/10.1016/J.FUTURE.2017.11.022

Kim, S. I., & Kim, S. H. (2022). E-commerce payment model using blockchain. *Journal of Ambient Intelligence and Humanized Computing*, *13*(3), 1673–1685. https://doi.org/10.1007/S12652-020-02519-5

Lamela, M. P., Rodriguez-Molina, J., Martinez-Nunez, M., & Garbajosa, J. (2022). A Blockchain-Based Decentralized Marketplace for Trustworthy Trade in Developing Countries. *IEEE Access*, *10*, 79100–79123. https://doi.org/10.1109/ACCESS.2022.3194511

Li, M., Shao, S., Ye, Q., Xu, G., & Huang, G. Q. (2020). Blockchain-enabled logistics finance execution platform for capital-constrained E-commerce retail. *Robotics and Computer-Integrated Manufacturing*, *65*. https://doi.org/10.1016/J.RCIM.2020.101962

Li, S. S., & Karahanna, E. (2015). Online recommendation systems in a B2C E-commerce context: A review and future directions. *Journal of the Association for Information Systems*, *16*(2), 72–107. https://doi.org/10.17705/1JAIS.00389

Li, X., & Huang, D. (2020). Research on Value Integration Mode of Agricultural E-Commerce Industry Chain Based on Internet of Things and Blockchain Technology. *Wireless Communications and Mobile Computing*, *2020*. https://doi.org/10.1155/2020/8889148

Liu, C., Xiao, Y., Javangula, V., Hu, Q., Wang, S., & Cheng, X. (2019). NormaChain: A blockchain-based normalized autonomous transaction settlement system for IoT-based e-commerce. *IEEE Internet of Things Journal*, *6*(3), 4680–4693. https://doi.org/10.1109/JIOT.2018.2877634

Liu, Z., & Li, Z. (2020). A blockchain-based framework of cross-border e-commerce supply chain. *International Journal of Information Management*, *52*. https://doi.org/10.1016/J.IJINFOMGT.2019.102059

Liu, Z. Y., & Guo, P. T. (2021). Supply Chain Decision Model Based on Blockchain: A Case Study of Fresh Food E-Commerce Supply Chain Performance Improvement. *Discrete Dynamics in Nature and Society*, *2021*. https://doi.org/10.1155/2021/5795547

Ngai, E. W. T., & Wat, F. K. T. (2002). A literature review and classification of electronic commerce research. *Information and Management*, *39*(5), 415–429. https://doi.org/10.1016/S0378-7206(01)00107-0

Rachana Harish, A., Liu, X. L., Zhong, R. Y., & Huang, G. Q. (2021). Log-flock: A blockchain-enabled platform for digital asset valuation and risk assessment in E-commerce logistics financing. *Computers and Industrial Engineering*, *151*. https://doi.org/10.1016/J.CIE.2020.107001

Risius, M., & Spohrer, K. (2017). A Blockchain Research Framework: What We (don't) Know, Where We Go from Here, and How We Will Get There. *Business and Information Systems Engineering*, *59*(6), 385–409. https://doi.org/10.1007/S12599-017-0506-0

Subramanian, H. (2018). Decentralized Blockchain-based electronic marketplaces. *Communications of the ACM*, *61*(1), 78–84. https://doi.org/10.1145/3158333

Sun, Y., Xue, R., Zhang, R., Su, Q., & Gao, S. (2021). RTChain: A Reputation System with

Transaction and Consensus Incentives for E-commerce Blockchain. *ACM Transactions on Internet Technology*, *21*(1). https://doi.org/10.1145/3430502

Taherdoost, H. (2023a). Smart Contracts in Blockchain Technology: A Critical Review. *Information (Switzerland)*, *14*(2). https://doi.org/10.3390/INFO14020117

Taherdoost, H. (2023b). Towards Nuts and Bolts of Conducting Literature Review: A Typology of Literature Review. *Electronics (Switzerland)*, *12*(4). https://doi.org/10.3390/ELECTRONICS12040800

Taherdoost, H., & Madanchian, M. (2023). Blockchain-Based E-Commerce: A Review on Applications and Challenges. *Electronics 2023, Vol. 12, Page 1889*, *12*(8), 1889. https://doi.org/10.3390/ELECTRONICS12081889

Treiblmaier, H., & Sillaber, C. (2021). The impact of blockchain on e-commerce: A framework for salient research topics. *Electronic Commerce Research and Applications*, *48*. https://doi.org/10.1016/J.ELERAP.2021.101054

Treichler, C. (2019). Consulting industry and market trends: A two-sided view. *Contributions to Management Science*, 253–272. https://doi.org/10.1007/978-3-319-95999-3_12

Wan, X., Yang, D., & Teng, Z. (2022). Blockchain digital technology empowers E-commerce supply chain sustainable value co-creation decisions and coordination considering online consumer reviews. *Applied Soft Computing*, *130*. https://doi.org/10.1016/J.ASOC.2022.109662

Wang, Y., Ma, H. S., Yang, J. H., & Wang, K. S. (2017). Industry 4.0: away from mass customization to mass personalization production. *Advances in Manufacturing*, *5*(4), 311–320. https://doi.org/10.1007/S40436-017-0204-7

Zhao, B., Jiang, X., Zhang, N., Guo, Q., & Song, R. (2022). Design and Application of e-Commerce Platform System Based on Blockchain Technology on the Internet of Things. *Wireless Communications and Mobile Computing*, *2022*. https://doi.org/10.1155/2022/4448588

Zhuansun, F., Chen, J., Chen, W., & Sun, Y. (2021). The Mechanism of Evolution and Balance for e-Commerce Ecosystem under Blockchain. *Scientific Programming*, *2021*. https://doi.org/10.1155/2021/5984306