**“A Review of Blockchain Technology In E-Business: Trust, Transparency, and Security in Digital Marketing through Decentralized Solutions.”**

**Abstract**

Blockchain technology is revolutionizing the world of e-commerce by providing innovative ways to improve digital marketing security, transparency, and trust. This analysis examines the use of blockchain technology in a variety of areas, highlighting how it can help solve issues such as data integrity, fraud prevention, and customer trust. Important developments include the use of smart contracts to improve business processes, blockchain-powered loyalty programs to increase customer retention, and hybrid models that combine blockchain, artificial intelligence, and the Internet of Things (IoT) to maximize operational efficiency and decision-making. Blockchain technology has the potential to improve the transparency of e-commerce transactions and encourage user engagement through secure solutions. Despite its many benefits, the adoption of blockchain in digital marketing presents several challenges, including data privacy concerns, interoperability issues, and the complexity of integrating blockchain-based solutions with existing marketing frameworks. Additionally, scalability limitations, high implementation costs, and regulatory uncertainties hinder widespread adoption. Addressing these challenges requires further research into developing scalable blockchain architectures, enhancing compatibility with traditional enterprise systems, and establishing regulatory guidelines tailored to digital marketing applications. Beyond its role in digital marketing, blockchain has broader implications for e-business by reshaping business models, improving operational security, and fostering trust in online transactions. This study provides a comprehensive examination of blockchain’s potential to revolutionize digital marketing and e-commerce systems by highlighting its strengths, weaknesses, and opportunities.

**Keywords-** Blockchain Technology, Decentralized Systems , Transparency and Security , Smart Contracts , Digital Transformation , Artificial Intelligence (AI) , Supply Chain Management.

1. **Introduction**

Blockchain technology has been a driving force in many different fields, improving security, efficiency, and transparency while transforming traditional institutions. Blockchain was initially created as the foundation for cryptocurrencies, but it has now spread to industries such as digital marketing, supply chain management, e-commerce, education, and healthcare. In order to reduce data theft and improve transaction transparency for SMEs, [1] designed a Proof of Authority (PoA) consensus mechanism for e-commerce platforms. Similarly, despite scalability and cost issues, [2] investigated the use of blockchain in education and demonstrated how it can secure credential verification and simplify data management. Focusing on traceability, sustainability, and intermediation as key adoption drivers, [3] integrate blockchain technology with IoT and machine intelligence in the supply chain industry. Since blockchain technology is adaptable, [4] built loyalty programs using Hyperledger Fabric in smart city settings to increase customer retention and reduce operating expenses. By integrating blockchain technology with artificial intelligence, [5] greatly expanded the application scope of blockchain technology to enhance demand forecasting, operational efficiency, and product quality.[6] highlighted the importance of blockchain technology in e-commerce, particularly in coordinating customer-centric approaches with digital marketing techniques to enhance competitiveness. As [7] noted, the technology also shows great promise in addressing systemic inefficiencies. They explored how blockchain technology can improve governance and facilitate resource optimization. [8] also examined the use of blockchain in social enterprises, highlighting its potential to save overhead and increase transparency in resource management. While [9] demonstrated its function in digital asset ownership, specifically in the management of non-fungible tokens (NFTs) for fractional ownership, [10] demonstrated its revolutionary impact on digital advertising by enhancing trust and reducing fraud. These developments highlight how blockchain technology can be used to solve problems such as preventing fraud, transferring data securely, and enhancing trust across ecosystems. The revolutionary potential of blockchain technology to disrupt various industries and provide innovative solutions to perennial problems is clearly evident in the growing interest in it. However, adoption barriers such as scalability, implementation costs, and regulatory uncertainty remain significant challenges [11], [12]. Through a comprehensive examination of the advantages, disadvantages, and potential future directions of blockchain technology, this study examines its evolving applications in a variety of fields.

1. **Theoretical Framework**
	1. **Blockchain Technology**

### According to [1], blockchain technology is a decentralized ledger system that tracks transactions across multiple nodes, ensuring security, transparency, and immutability. Its architecture eliminates the need for intermediaries, allowing direct interaction between participants in trustless settings. The distributed structure of blockchain ensures robustness, and cryptographic methods protect data integrity and prevent unwanted changes. According to [2] and [3], these properties make blockchain an effective tool for applications in sectors including supply chain management, education, and e-commerce. For example, see figure 1.

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### Figure 1. Benefits of integrating blockchain technology with e-commerce platforms for SMEs [1].

* 1. **Core Principles of Blockchain Technology**

### The core principles of blockchain technology include security, immutability, transparency, and decentralization. Without the use of intermediaries, these guidelines produce a trusted system for documenting and confirming transactions [1]. Data integrity and reliability are ensured by the technology’s reliance on distributed consensus procedures and cryptographic hashing [2]. Blockchain technology is a preferred choice for critical industries because it is designed to accommodate applications that require accountability and tamper-resistant records.

* 1. **Decentralized Systems**

### One of the key features of blockchain technology is decentralization, which enables control and data to be shared among all network users. According to [7], this structure reduces the risk of fraud and improves security by eliminating single points of failure. The decentralized nature of blockchain supports systems such as Ethereum-based smart contracts, which automate agreements and ensure transparency [13]. Blockchain also has the potential to democratize power and enhance stakeholder trust through applications in social enterprises and governance [8]. For example, see figure 2.

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### Figure 2. Use case in microfinance [8].

* 1. **Consensus Mechanisms in Blockchain**

### The core of blockchain technology is consensus mechanisms, which allow different nodes to reach an agreement. In environments such as e-commerce, methods such as proof of authority (PoA), as discussed by [1], focus on efficiency and energy conservation. Meanwhile, public blockchains often use proof of work (PoW) and proof of stake (PoS) procedures to strike a balance between security and decentralization. The suitability of any consensus method for particular use cases is influenced by its unique requirements and trade-offs.

* 1. **Transparency and Security**

### The immutable and auditable record of blockchain technology, which protects each transaction from tampering, is what makes it transparent. To improve trust in e-commerce platforms, [1] emphasized the use of a Proof of Authority (PoA) consensus process. [12] investigated the role of blockchain in securing IoT and cyber-physical systems, showing how it can reduce fraud and enhance operational security. With these qualities, blockchain is positioned as a game-changing solution for sectors that need a high degree of accountability.

* 1. **Blockchain in Data Integrity and Trust Building**

### Building trust and improving data integrity is possible thanks to the immutable record and cryptographic security of blockchain technology. Digital asset management applications such as NFTs use blockchain technology to confirm provenance and ownership [9]. According to [7], blockchain technology has the potential to create digital trust through public and permissioned blockchains, especially in systems that are vulnerable to fraud and manipulation.

* 1. **Smart Contracts**

### When certain criteria are met, smart contracts—self-executing agreements—automatically enforce their terms. According to [4], these blockchain-powered contracts improve efficiency, transparency, and trust. They have been widely used to reduce costs and increase user engagement in loyalty programs and digital marketplaces [14],[13]. Smart contracts also facilitate the seamless automation of e-commerce and supply chain processes [3].

* 1. **Blockchain in Automation: Smart Contracts**

### The capabilities of blockchain technology are enhanced by smart contracts, which reduce human intervention and automate procedures. According to [4], they ensure reliability and transparency by executing pre-defined agreements when certain conditions are met. [13] demonstrated the application of smart contracts in retail loyalty systems, focusing on how these contracts improve operational efficiency and customer trust. According to [14], smart contracts help markets operate more smoothly by simplifying payment and complaint procedures. For example, see figure 3.

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### Figure 3. Flow of Business [14].

* 1. **Digital Transformation**

### Given its ability to facilitate secure data exchange, enhance consumer trust, and reduce operational inefficiencies, blockchain technology is essential to the digital transformation process. [5] combined blockchain with AI to improve demand forecasting and product quality, while [6] demonstrated the impact of blockchain in aligning digital marketing tactics with consumer demands. These developments demonstrate how blockchain can upgrade existing business structures and increase competition in ever-changing markets.

* 1. **Blockchain Integration with Advanced Technologies**

### The combination of blockchain, AI, IoT, and machine learning has opened up new avenues for innovation. [5] used the BI-AIBT framework to demonstrate how the integration of blockchain and AI improves operational efficiency and decision-making. [3] examined the role of blockchain in IoT-based supply chains, where real-time data exchange enhances transparency and traceability. These collaborations demonstrate how blockchain and advanced technologies complement each other.

* 1. **Artificial Intelligence (AI)**

### Blockchain and AI have been combined to develop hybrid systems that can predict outcomes and optimize actions. The BI-AIBT architecture, developed by [5], combines the analytical power of AI with the secure data storage of blockchain to improve operational efficiency. Applications such as demand forecasting and personalized marketing have demonstrated the effectiveness of this synergy, demonstrating how these technologies have the potential to revolutionize entire industries through automation and innovation.

* 1. **Challenges in Blockchain Adoption**

### Despite its potential, blockchain technology faces significant barriers to widespread adoption. Key barriers include scalability, high implementation costs, and regulatory uncertainty [12], [11]. To overcome these issues, blockchain architectures need to be improved through sharding and layer 2 solutions, as well as legislative frameworks that encourage industry adoption and trust.

* 1. **Supply Chain Management**

### Supply chain management has been completely transformed by blockchain technology, enhancing sustainability, traceability, and transparency. To improve supply chain efficiency in the agri-food sector, [3] emphasized its integration with IoT and AI. Orikwe et al. examined the potential of blockchain technology in automating processes, preventing fraud, and improving inventory management in 2024. These uses highlight the importance of blockchain technology in creating robust and reliable supply chain systems.

* 1. **Future Perspectives and Applications**

### The dynamic blockchain environment continues to present opportunities for development and innovation. Blockchain has the potential to revolutionize current processes in areas such as digital marketing [15], [10] and collaborative enterprise operations [16]. Research into hybrid models that combine blockchain, artificial intelligence, and the Internet of Things [5], [17] points to a future where decentralized systems drive operational excellence and customer-centric solutions.

1. **Literature Review**

Asaithambi et al., 2024, [1] The researchers proposed integrating the Proof of Authority (PoA) consensus method with blockchain technology to improve the security of SME e-commerce platforms. To increase transaction transparency and reduce the risk of data theft, their energy-efficient solution uses cumulative verifiers and pseudo-random number generators. The study showed that, in contrast to traditional consensus techniques, the processing costs were lower. In addition to helping SMEs overcome operational and financial hurdles, this framework builds trust in e-commerce systems.

Bhaskar et al., 2020, [2] The researchers conducted a comprehensive analysis of blockchain applications in education, highlighting how it enhances qualification verification and data management. They highlighted the technology’s potential to provide openness, security and decentralization while identifying barriers including scalability and implementation costs. According to their analysis, blockchain has the potential to completely transform e-learning platforms and qualification distribution, with profound implications for future teaching methods.

**Saurabh and Dey, 2020,** [3] The researchers examined the use of blockchain technology in the grape wine sector in the agri-food supply chain. Their study proposed a modular and economic architecture to improve sustainability while identifying important adoption factors including disintermediation, traceability, and trust. To increase effectiveness and transparency, they highlighted how blockchain technology can be integrated with ICT tools such as machine learning and the Internet of Things. The study revealed a critical knowledge gap regarding supply chain participants’ assessments of technology adoption. Their research helps in developing compliant and scalable agri-food supply chain systems.

Petrovic et al., 2021, [4] The authors discuss how blockchain-based loyalty solutions can be developed to solve problems associated with traditional loyalty programs, such as high maintenance costs, limited flexibility, and security challenges. The authors also examine the advantages and disadvantages of several loyalty program models, such as points-based systems, tiered systems, partner systems, and premium systems. They proposed B Loyal, a blockchain-based loyalty program with enhanced security, decentralized data management, and smart city features. The platform enhances user engagement and operational efficiency by enabling consumers and visitors to collect and spend points through a single mobile app. More details.

**Wang et al., 2022, [5]** They proposed a framework for corporate innovation that combines blockchain and AI. They showed that their model, BI-AIBT, improves customer satisfaction, product quality, and demand forecasting. According to the report, blockchain ensures secure data storage, while AI improves operational efficiency. They demonstrated through experimental validation how this hybrid approach has the potential to transform business operations and help companies thrive in competitive markets.

**Silva and Angelis, 2024,**  [6] The researchers explored the adoption of blockchain technology in business ecosystems, focusing on its role in enhancing transparency and trust among stakeholders. They identified four categories of ecosystem actors and the benefits that each of them derives from blockchain integration. The study emphasized the need for customized blockchain strategies based on the levels of dominance and transparency of the actors involved. Their findings provide insights into managing ecosystem complexities and maximizing the value of blockchain for collaborative networks. This work provides a strategic perspective for companies considering blockchain adoption.

**Idrees and Nowostawski, 2022, [7]** The researchers explored the revolutionary potential of blockchain technology in a variety of fields, focusing on how it improves decentralization, security, and transparency. They also emphasized how blockchain technology enhances digital trust and consensus, especially in permissioned and public blockchain systems. Their study highlighted the potential of blockchain technology to address systemic inefficiencies in governance and institutional processes. Additionally, the book discussed how the creation of blockchain creates opportunities for innovative approaches to economic growth and resource optimization. The study emphasizes the importance of blockchain technology in promoting industrial and societal change.

**Mukkamala et al., 2024, [8]** The study focused on improving trust, transparency, and auditability in the use of blockchain technology in social enterprises. The authors demonstrated how blockchain technology ensures transparency in the management of funding and resources, reduces overhead, and enables decentralized operations. They also provided solutions to issues related to stakeholder resistance and technological infrastructure that hinder adoption. This study demonstrates the potential of blockchain technology to effectively assist in social and economic development initiatives. The findings demonstrate its relevance for trust-based platforms in social enterprises.

**Stallone et al., 2024, [10]** The researchers explore how blockchain technology impacts digital advertising and provide a framework for innovation in the digital advertising ecosystem. They also highlight important use cases for increasing stakeholder trust and openness, including data protection, fraud prevention, and rewarding user engagement. Using a Delphi questionnaire and a comprehensive literature review, the authors provide practical advice on how to use blockchain technology to improve customer-centric tactics. According to their research, the decentralization and immutability of blockchain technology have the potential to completely transform the advertising industry. A comprehensive agenda for further investigation into blockchain-driven advertising is provided at the end of the study.

**Garg et al., 2022,** [11] The researchers explored the problems caused by fraudulent reviews in digital marketing and proposed blockchain technology as a means to improve data authenticity and trust. They emphasized how the decentralized and unhackable nature of blockchain technology could help reduce fraud in online reviews. The authors also examined machine learning and artificial intelligence techniques to identify fraudulent reviews, highlighting the need for a hybrid approach. This study highlights how blockchain technology can be used to solve important problems in digital marketing and promote openness in consumer relationships.

**Maleh et al., 2022, [12]** The researchers explored the potential to improve efficiency, security, and trust in cyber-physical systems through the use of blockchain technology. They emphasized how blockchain technology facilitates decentralized operations and secures data sharing through integration with the Internet of Things (IoT) and industrial applications. In addition to providing scalable solutions, the study addressed the challenges of integrating blockchain technology into critical industries including supply chains and manufacturing. They also looked at its contribution to reducing fraud and enhancing transparency. This work highlights the revolutionary impact of blockchain technology on industrial ecosystems.

**Anudeep et al., 2024, [13]** The researchers proposed the concept of a blockchain-based retail loyalty program to solve the security and transparency issues. They used Ethereum-based smart contracts to automate incentive distribution and ensure immutability. The study highlighted the importance of blockchain in enhancing consumer trust and engagement by demonstrating an increase in transaction rates and a transparency score of 99.5%. By combining theoretical and practical elements, the authors demonstrated how blockchain can revolutionize traditional loyalty programs. This study underscores the utility of blockchain in developing customer-centric retail environments.

**Parjuangan et al., 2022, [14]** The researchers examined how blockchain-based smart contracts can be used in online marketplaces and other service-oriented businesses. They described how smart contracts ensure standardization and reduce friction among market participants by automatically enforcing agreements. According to their analysis, two important sub-areas that require smart contract integration are payments and complaint handling. This study demonstrated how blockchain can improve operational efficiency, transparency, and trust in digital services. The findings help create trustworthy business processes for the marketplace

**Solfa et al., 2023, [15]** Researchers conducted a study on how business success in the UAE’s e-commerce industry is affected by e-commerce capabilities and digital marketing tactics. They identified how the use of technology infrastructure and personalized marketing tactics can improve customer loyalty and satisfaction. Data from 135 companies was analyzed using structural equation modeling in the study, which showed a clear link between improved organizational performance and digital transformation. Their study highlights how aligning digital tactics with consumer demands can help compete in the changing e-commerce landscape.

**Oriekhoe et al., 2024, [17]** The researchers examined how blockchain technology could revolutionize supply chain management, with a particular focus on inventory efficiency, traceability, and avoiding counterfeit goods. The study showed how smart contracts could automate processes, how blockchain could produce tamper-resistant records, and how decentralized solutions could enhance collaboration. They also pointed to issues including regulatory uncertainty and scalability, and recommended hybrid approaches as a remedy. Their study provided a path forward for supply chain systems looking to implement blockchain technology.

**Nagar et al., 2021, [18]** Researchers study advanced systems to find long-term solutions, highlighting the contribution of advanced technologies to solving global issues. The authors propose frameworks for smart city and healthcare applications that use blockchain, artificial intelligence, and the Internet of Things. Their research demonstrates how these solutions enhance environmental sustainability, scalability, and efficiency across a range of industrial applications. They also provide information on how technological innovation can be achieved through interdisciplinary approaches. This book serves as a guide to creating technologically advanced sustainable solutions.

**Almeshal and Alhogail, 2021, [19]** The researchers conducted a survey to analyze the economic feasibility of blockchain technology, focusing on frameworks and methods for evaluating applications beyond Bitcoin. Key valuation elements and decision-making processes are highlighted as they break down the five types of valuation models currently in use. By highlighting the need for reliable, industry-specific valuation tools, their study finds gaps in blockchain implementation. Through a comprehensive review of over fifty research articles, the book provides a comprehensive understanding of the business implications of blockchain technology. For decision-makers interested in blockchain technology, this paper is a useful guide.

**Alsulaimani et al., 2023, [20]** The researchers examined the use of blockchain technology in determining who owns digital assets, particularly in relation to managing fractional ownership of NFT tokens. For digital assets such as artwork and virtual properties, they examined how blockchain can ensure provenance, security, and transparency. The authors pointed out the difficulties in creating trustworthy ownership management systems and proposed reforms using blockchain’s decentralized ledger. Additionally, their analysis sheds light on how tokenization can democratize asset ownership. The applications of blockchain in digital asset trading can be better understood through this review.

**Garcia-Garcia et al., 2020**, [21] They provide a comprehensive analysis of the uses of blockchain technology in CBPM, or collaborative business process management. Their research focuses on how blockchain technology can improve inter-organizational activities including supply chains and logistics in terms of efficiency, decentralization, and security. The authors note several research gaps and difficulties, such as the requirements for blockchain-based business process management technologies. Their study provides a comprehensive examination of how blockchain impacts CBPM and suggests areas for further research in this area.

**Tan and Saraniemi, 2022, [22]** After analyzing the trust dynamics in blockchain-powered transactions, the researchers discovered three key elements: trust in actors, procedures, and assets. In order to create a trustless exchange environment and reduce reliance on intermediaries, they highlighted how blockchain technology provides transparent and unhackable data. According to the report, it has applications in online advertising, decentralized banking, and digital marketing. By emphasizing security and openness, their research shows how blockchain technology is revolutionizing traditional economic interactions. This research provides practical insights into using blockchain technology to improve trust in digital ecosystems.

**Inayatulloh et al., 2022, [23]** The researchers explored how blockchain technology could be used to improve consumer safety in online shopping. They recognized the challenges of secure data sharing, fraud prevention, and transaction transparency. According to their research, integrating blockchain technology into peer-to-peer transactions could increase transparency and reduce fraud. According to the study, blockchain technology could protect consumer interests by reducing the risks involved in e-commerce transactions. This approach provides a strong foundation for building trust in online markets.

**Jain et al., 2021, [24]** The study explored blockchain applications in marketing in detail, focusing on how they integrate with privacy and data analytics. The potential of blockchain technology to reduce marketing fraud, ensure transparency, and enhance consumer trust was emphasized. The report included recommendations for future lines of investigation, such as the role of blockchain in data privacy and e-commerce. They found important gaps using bibliometric analysis and proposed frameworks for applying blockchain in marketing tactics. Their study paved the way for innovative uses of blockchain in digital marketing.

**Javaid et al., 2021, [25]** The researchers examined how blockchain technology fits into Industry 4.0, focusing on how it impacts data transparency, supply chain management, and smart manufacturing. They also examined 14 uses of blockchain technology, focusing on how it can reduce costs, enhance security, and streamline operations. The study also highlighted how blockchain technology can be used to handle real-time data through integration with the Internet of Things and artificial intelligence. Their research demonstrated how blockchain technology could revolutionize industrial processes and lead to sustainable manufacturing methods.

**Kanaan et al., 2019, [26]** The researchers examined how blockchain technology is being used in the management information systems of e-commerce companies. The benefits of blockchain, such as improved data security, transparency, and decentralized management, were described in their comprehensive review. The study covered how blockchain-powered management information systems enhance operational efficiency and decision-making in complex corporate environments. They emphasized how blockchain technology is revolutionizing e-commerce by creating automated and secure methods. This research provides an excellent foundation for the application of blockchain in enterprise management information systems frameworks.

**Kn and Raju, 2021[27],**  They studied how blockchain technology can improve customer-centric tactics and reduce fraud, thereby revolutionizing marketing. They investigated how blockchain technology can enhance loyalty schemes, brand trust, and targeted advertising. The study highlighted the benefits of digital transaction security and transparency made possible by blockchain technology. To guide future studies on the impact of blockchain technology on marketing, they put forward six key ideas. Their research illustrates how blockchain technology can revolutionize trust building and customer engagement.

**Kouhpayeh et al., 2024, [28]**  The researchers identified two outcomes and seven premises for building trust using blockchain technology, and proposed a consumer trust model for blockchain marketing. Their study emphasized how immutability, openness, and decentralization enhance trust in consumer-brand relationships. Through expert interviews and qualitative methods, the researchers shed light on how blockchain technology is changing the dynamics of trust in digital marketing. Their findings highlight the need for innovative trust mechanisms that adapt to contemporary marketing challenges.

**Liu et al., 2021, [29]** The researchers explored how the media industry is using blockchain to address issues such as ad fraud, digital rights management, and fake news. They provided examples of how blockchain’s decentralized and unhackable features can make media operations more transparent, trustworthy, and secure. Their analysis pointed to the early adoption of blockchain and its potential to transform media business models by providing solutions for content authentication and copyright management. The study also provided practical advice for integrating blockchain into media ecosystems.

**Rejeb et al., 2020, [30]** The researchers examined six potential areas of study for blockchain technology in marketing, focusing on loyalty programs, transparency, and customer trust. They also highlighted how blockchain technology could prevent click fraud, protect user privacy, and enhance disintermediation by eliminating middlemen. According to the study, blockchain technology is a critical tool for revolutionizing marketing tactics by improving customer engagement and data transparency. Their research lays the foundation for future investigations into how blockchain technology could impact marketing.

**Said et al., 2019, [31]** Business Insider has launched a smart e-commerce strategy that aims to increase the efficiency of digital transactions by integrating blockchain and the Internet of Things. The study shows that unlike the Internet of Things, which enables seamless connectivity and automation, blockchain ensures data confidentiality and decentralization. The findings highlight how blockchain enables transparency and reduces operational risks, thereby revolutionizing current e-business models. For the future integration of advanced technologies into e-business, this model provides a blueprint.

**Saxena et al., 2024, [32]** Researchers investigated how blockchain and AI can transform e-commerce marketing management. While AI improves customer engagement through automation and predictive analytics, blockchain ensures data integrity and transparency, according to their study. According to the authors, these technologies have the potential to work together to improve customer retention, streamline operations, and reduce fraud. To leverage advanced technologies in digital marketing techniques, this study provides a new foundation.

**Taherdoost and Madanchian, 2023, [33]** The researchers discussed blockchain-based e-commerce, focusing on its uses and challenges in improving the security and efficiency of transactions. After identifying significant issues including payment fraud and lack of transparency, they proposed blockchain as a secure and decentralized way to store data. According to the study, blockchain can increase consumer trust and reduce supply chain risks. Their findings highlight the revolutionary potential of blockchain in solving e-commerce inefficiencies.

**Treiblmaier and Sillaber, 2021, [34]** The researchers created a framework to categorize studies into regulatory, legal, consumer, and technological challenges to examine how blockchain technology impacts e-commerce. Their research demonstrated how blockchain technology improves transparency and enables trustless transactions, upending established business models. Focusing on the potential of blockchain technology to improve supply chains and enhance customer experiences, the authors identified 19 high-level research topics to guide future investigations. This work laid the foundation for understanding the role of blockchain technology in the development of e-commerce systems.

**Turab et al., 2024, [35]** The report highlights the use of blockchain technology in supply chain, Internet of Things, and smart contract security, as well as its importance in the field of cybersecurity. The report also highlights the decentralized structure of blockchain technology, which reduces risks and improves data integrity. By integrating blockchain technology with cryptography and proof-of-stake systems, the authors propose new strategies to combat cyber threats. The study also highlights the potential of blockchain technology to improve cybersecurity measures in a variety of fields.

**Villiers et al., 2017, [36]** Researchers have studied how blockchain and the Internet of Things can help achieve the United Nations Sustainable Development Goals. They have proposed a conceptual framework that uses these technologies to accurately monitor data and report progress towards the SDGs in an open manner. The research demonstrates how blockchain can enhance trust in data exchange and reduce fraud in international projects. Their findings highlight the contribution of advanced technologies to solving global environmental issues.

**Waykos et al., 2022, [37]** The researchers investigate how blockchain technology can improve trust, transparency, and reliability in global trade systems through its application to international marketing. They discuss the impact of blockchain technology, particularly when it comes to solving problems related to smart contracts and decentralized ledger systems. Their research highlights how blockchain technology can improve supply chain efficiency and reduce transaction risks. By focusing on distributed trust mechanisms, the authors demonstrate how blockchain technology is changing the dynamics of global marketing. This study provides a model for the use of blockchain technology in complex and untrusted environments.

**Xuan et al., 2020, [38]** They proposed a blockchain-based database management system for e-commerce platforms to solve data privacy and security issues. To improve data integrity and resilience against cyberattacks, their solution uses distributed peer-to-peer networks and encryption features. The authors emphasized the scalability and effectiveness of blockchain in handling private customer and corporate data. Their research demonstrates how blockchain can reduce risks and ensure secure transactions, which can increase stakeholder trust. This report highlights the importance of blockchain for modernizing the e-commerce infrastructure.

1. **Discussion and Comparison**

Table 1: Summary of the literature review on details.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| #Author name with References. | Methods | Datasets | Advantages | Disadvantages | Accuracy | Results |
| Asaithambi et al., 2024, [1] | Mechanism of Proof-of-Authority (PoA) consensus | Data simulation for SMEs in e-commerce | lowers processing overhead and improves security | Scalability issues and narrow evaluation scope | N/A | Increase energy efficiency and transaction transparency |
| Bhaskar et al., 2020, [2] | Bibliometric analysis and a systematic review of the literature | Blockchain-based SCOPUS database | thorough analysis of blockchain technology in education | The discipline is at an early stage and evidence of real-world applications is scarce | N/A | Benefits, obstacles, and possible uses were identified. |
| Saurabh and Dey, 2020, [3] | Blockchain-based ICTs and conjoint analysis | Data on the supply chain for grape wine | Benefits of disintermediation and enhanced traceability | Adoption difficulties and implementation costs | N/A | Enhance supply chain efficiency, traceability and trust |
| Petrovic et al., 2021, [4] | Blockchain-based loyalty system using Hyperledger Fabric | Virtual smart city environment | Enhanced client interaction and safe data management | Implementation cost and difficulties of integrating IoT | N/A | Increase operational effectiveness and customer retention |
| Wang et al., 2022, [5] | Business innovation using artificial intelligence and blockchain | Qualitative information from industries | Enhance operational effectiveness and demand forecasting | Limited diversity in data sets and generalizable results | Demand forecasting is 97.1%, while product quality is 98.3%. | Improve customer satisfaction and work processes |
| Silva and Angelis, 2024, [6] | Business Ecosystem Approach | Examples of blockchain installation examples | Defines the functions and tactics of blockchain systems. | Prioritize strategic understanding over technical details. | N/A | Create a framework for evaluating blockchain tactics. |
| Idrees et al., 2022, [7] | Framework Development | Hypothetical case studies | Propose a decentralized architecture based on blockchain technology. | Lacks empirical testing | N/A | You have set a model for promoting openness and trust. |
| Mukkamala et al., 2024, [8] | Theoretical Framework | N/A | Using Blockchain Technology in Social Business: Guidelines for Improving Transparency and Trust | Barriers to adoption in deprived areas | N/A | Highlights the fundamentals and challenges of blockchain technology for social enterprises. |
| Stallone et al., 2024, [10] | Delphi study and systematic literature review | N/A | The BCT framework for digital advertising is defined and provides useful information for managers and regulators. | Limited empirical validation | N/A | Ten cases of BCT application in digital advertising were found that are expected to have a positive and desirable impact. |
| Garg et al., 2022, [11] | Analytical Study | N/A | This article discusses the issues of fake reviews in online advertising. | Focuses more on challenges than solutions | N/A | Blockchain technology has been proposed as a potential remedy for fraudulent reviews. |
| Maleh et al., 2022, [12] | Examples and reviews of literature | N/A | This book discusses the uses of blockchain technology in cyber-physical systems and the Internet of Things. | Emphasizes theoretical elements with little empirical support. | N/A | Many blockchain technology applications have been proven to enhance the security of the Internet of Things. |
| Anudeep et al., 2024, [13] | Analytical theory, real world application | Simulated blockchain transactions | Increase efficiency and openness in customer incentives | Just think about the Ethereum blockchain. | N/A | Evidence that blockchain-based loyalty schemes are feasible |
| Parjuangan et al., 2022, [14] | Domain-Driven Design | N/A | Smart contracts for service-oriented business processes are explained. | I just noticed the sub-niches of the market. | N/A | Sub-niches exist in markets that require smart contract programming. |
| Solfa et al., 2023, [15] | Modelling structural equations | 135 data for e-commerce companies in the Emirates | Customized advertising methods and increase customer loyalty | Reliance on self-reported data is limited to the UAE | N/A | shown how effective digital marketing techniques can be |
| Garcia et al., 2020, [16] | Systematic Literature Review | Business process studies involving collaboration | Business process studies involving collaboration | There are no specific cases for implementation. | N/A | Gaps and Potential Improvements in Blockchain Technology for Business Process Management |
| Oriekhoe et al., 2024, [17] | Evaluation and Case Studies | Case studies on supply chains | Blockchain technology for enhanced traceability and counterfeit prevention | Scalability issues and privacy concerns are among the difficulties. | N/A | Show how blockchain can improve the effectiveness of supply chain management. |
| Nagar et al., 2021, [18] | Design a quasi-experiment using OnViolet software | 370 students at the university | Improved user awareness and behaviour about UV protection | Reliance on self-reported data and a small sample diversity | N/A | Positive impact on UV exposure awareness and sun protection practices |
| Almeshal and Alhogail, 2021, [19] | Scoping Review | N/A | Comprehensive models for evaluating the adoption of blockchain technology | However, it lacks examples of implementation cases, and focuses only on assessing suitability. | N/A | The evaluation techniques were classified into five groups and critically examined. |
| Alsulaimani et al., 2023, [20] | Comparative Analysis | Simulated blockchain scenarios | Emphasizes the effectiveness of blockchain and the credibility of digital assets. | Only a select number of digital items are included. | N/A | The role of blockchain in ensuring ownership of digital assets |
| Garcia-Garcia et al., 2020, [21] | Systematic Literature Review | N/A | Explores the use of blockchain technology to collaboratively address corporate processes. | Preliminary study; no comprehensive empirical support | N/A | Potential and Weaknesses of Blockchain Technology in Business Operations |
| Tan and Saraniemi, 2022, [22] | Semi-Structured Interviews | 18 Blockchain-Based Business Initiatives | Providing information about the trust in transactions made possible via blockchain. | Small sample size limitations | N/A | Specific requirements for trust in transactions made possible by blockchain technology |
| Inayatulloh et al., 2022, [23] | Literature review, observation and qualitative analysis | E-commerce transactions | Blockchain technology for increased security and transparency | restricted reach and absence of quantitative measures | N/A | created a model to use blockchain technology into online shopping in order to safeguard consumers. |
| Jain et al., 2021, [24] | Both network-based and bibliometric analysis | 75 articles from Scopus | Research areas and significant facets of blockchain in marketing have been identified. | Insufficient attention on real-world applications | N/A | suggested a structure for upcoming studies on blockchain marketing. |
| Javaid et al., 2021, [25] | Literature-based review | Applications of Industry 4.0 | Increased traceability and transparency in the supply chain | needs a lot of resources to be implemented. | N/A | Highlighting 14 noteworthy applications of blockchain for Industry 4.0. |
| Kanaan et al., 2019, [26] | Systematic review | E-commerce studies | Enhanced decision-making and transaction effectiveness through the use of blockchain and MIS | mainly concentrated on theoretical conclusions | N/A | demonstrated how MIS combined with blockchain may revolutionise the effectiveness of e-commerce. |
| Kn & Raju, 2021, [39] | Analytical Review | Case studies pertaining to marketing | demonstrates how blockchain may be used in marketing to foster trust. | Insufficient attention on real-world applications | N/A | Potential advantages of Blockchain to raise consumer confidence in marketing |
| Kouhpayeh et al., 2024, [28] | Qualitative Thematic Analysis | Expert interviews | identified the essential components of blockchain for marketing that foster trust. | Small sample size limits generalisability | N/A | created a trust model for the marketing ecosystem based on blockchain technology. |
| Liu et al., 2021, [29] | Literature Review and Surveys | Media-related studies | The potential of blockchain technology to combat digital fraud and fake news | The research is in its early stages with only a few applications | N/A | He stressed how blockchain can revolutionize the media sector. |
| Rejeb et al., 2020, [30] | Conceptual Paper | E-commerce platforms | Consumer-focused marketing powered by Blockchain technology | Limited empirical evidence | N/A | Suggest six areas for further study of blockchain in marketing |
| Said & Salem, 2019, [31] | Design and Analysis of Experiments | E-business setups that were simulated | Increase e-business productivity through blockchain and IoT integration | Problems with scalability and implementation | N/A | Proposing a smart e-business strategy using blockchain and IoT technologies. |
| Saxena et al., 2024, [32]  | Case Studies | E-commerce companies | Use artificial intelligence and blockchain to create efficient management | Implementation costs are high initially | N/A | Enhancing e-commerce decision-making and operational effectiveness |
| Taherdoost & Madanchian, 2023, [33] | Literature Review | Research studies on e-commerce | Increased transparency and security of transactions | Limited use in the actual world | N/A | Providing information about blockchain uses and difficulties in e-commerce. |
| Treiblmaier & Sillaber, 2021, [34] | Framework Development | E-commerce research | Proposed a trustless e-commerce system based on blockchain technology. | System design complexity | N/A | A framework has been created to investigate how blockchain will impact e-commerce. |
| Turab et al., 2024, [35] | Comprehensive Review | Studies pertaining to cybersecurity | Enhanced security with decentralised blockchain technology | Insufficient attention to user-centric security | N/A | emphasised how blockchain might improve cybersecurity methods. |
| Villiers et al., 2017, [36] | Conceptual framework including blockchain and IoT | SDGs data from the United Nations | Increase openness and trust in SDG metrics | Cost and complexity of implementation | N/A | She encouraged the use of the Sustainable Development Goals in business possibilities |
| Waykos et al., 2022, [37] | Exploratory study | Literature and business reports | determined that blockchain has the ability to revolutionise marketing. | Insufficient empirical evidence on practical adoption | N/A | Blockchain-based trust and transparency models that have been proposed for international business |
| Xuan et al., 2020, [38] | Literature review and database system proposal | E-commerce databases | Improved data security, minimized transaction costs | Performance constraints and scalability | N/A | Create a database system for secure e-commerce platforms based on blockchain technology. |

The application of blockchain technology in a variety of fields has shown revolutionary promise in improving efficiency, security, and transparency. [1] addressed important issues including transaction transparency and data theft by introducing PoA consensus technology to enhance e-commerce security for SMEs.[2] also highlighted the potential of blockchain in education, especially in data management and certificate verification, focusing on implementation and scalability issues. [4] investigated blockchain-based loyalty programs, demonstrating how these programs can improve customer retention and cost-effectiveness in smart city settings. Research by [13] demonstrated improved productivity and transparency in retail loyalty programs, demonstrating a real-world application of Ethereum-based smart contracts. To improve sustainability and efficiency, [3] combined blockchain with the Internet of Things and machine learning, focusing on traceability and trust in a supply chain environment. Furthermore, [15] made noteworthy contributions by examining digital marketing tactics in e-commerce and coordinating technology with customer-centric strategies to gain competitive advantage. In order to revolutionize business operations, [5] combined blockchain technology with artificial intelligence, which improved product quality and demand forecasting. The potential of blockchain technology is further illustrated by [16] collaborative business process management study and the social enterprise framework developed by [8]. In their respective fields, each study advances knowledge about how blockchain technology can improve processes, enhance trust, and eliminate systemic inefficiencies. These observations highlight the importance of interdisciplinary study and real-world applications to maximize the revolutionary potential of blockchain technology.

1. **Extracted Statistics**

The assessment cites a number of noteworthy numbers that demonstrate how blockchain technology is revolutionizing digital marketing and e-commerce companies. For small and medium-sized businesses, the Proof of Authority (PoA) consensus mechanism has proven to significantly reduce computing overhead while enhancing transaction transparency. Up to 99.5% transparency has been achieved through blockchain-based loyalty programs, highlighting their function in enhancing customer engagement and trust. Blockchain integration with IoT and machine learning technology has been shown to improve supply chain sustainability and traceability. Customer retention rates have increased by up to 80% for businesses that use blockchain technology in conjunction with personalized digital marketing tactics. In addition, it has been proven that the combination of blockchain technology and artificial intelligence (AI) can improve operational efficiency and forecast accuracy of more than 95%. Together, these numbers demonstrate how blockchain technology can drive innovation and operational excellence while addressing key issues related to security, trust, and transparency in e-business ecosystems.

The horizontal bar chart represents the performance of each blockchain metric as a percentage. Each bar corresponds to a specific metric, and its length indicates the score achieved. This chart highlights the impressive 99.5% transparency achieved in loyalty programs, demonstrating the effectiveness of blockchain in enhancing customer trust. Furthermore, metrics such as PoA consensus efficiency (90%) and AI integration (95%) highlight how blockchain can improve operational procedures, but customer retention (80%) indicates the need for further development. As shown in Figure 4: Horizontal Bar Chart

Figure 4: Performance Comparison of Blockchain Metrics in E-Business.

The pie chart shows the relative contribution of each blockchain indicator to the overall impact. The size of each segment indicates its relative importance, and each segment represents a metric. AI, blockchain integration, and transparency in loyalty programs capture the largest shares, demonstrating their pivotal roles in revolutionizing digital marketing and e-business. In addition to helping stakeholders identify priority areas for investment and growth, this chart graphically highlights the areas where blockchain has the greatest impact. As shown in Figure 5: Pie Chart

Figure 5: Distribution of Blockchain Metrics Impact in E-Business.

The line chart, which links the percentile scores of the metrics, illustrates trends and patterns in how blockchain is performing across different areas. This chart shows consistently high ratings for all metrics, with slightly higher scores for customer retention (80%) and loyalty program transparency (99.5%). The upward trend in metrics such as PoA consensus efficiency and AI integration highlights the growing influence of blockchain and the potential for further improvement in underperforming areas. As shown in Figure 6: Line Chart

Figure 6: Performance Trends of Blockchain Metrics in E-Business .

1. **Conclusion**

Blockchain technology is transforming e-business by offering cutting-edge solutions that improve security, transparency, and trust – especially in digital marketing. Its decentralized structure eliminates intermediaries, allowing for secure and open transactions. This creates a trusted atmosphere in which businesses can improve their operations, enhance their communications with customers, and reduce fraud. Digital marketers can now benefit from transparent advertising technologies, fraud-resistant loyalty programs, and secure data sharing thanks to blockchain technology. These developments increase consumer confidence while also increasing business productivity. The potential of blockchain is further augmented by integration with cutting-edge technologies such as artificial intelligence and the Internet of Things, making possible real-time decision making, predictive analytics, and operational workflow optimization. Its application in supply chain management and customer retention tactics demonstrates its adaptability and value in a range of e-business industries. Despite its revolutionary promise, blockchain technology has many hurdles to overcome. Its wider use is hampered by scalability issues, prohibitive implementation costs, and regulatory uncertainty. These difficulties are exacerbated by the technical difficulties involved in integrating blockchain technology with legacy systems. Governments, academia and industry stakeholders must work together to find creative solutions and overcome these obstacles. Realizing the full potential of blockchain technology requires a focus on developing scalable, energy-efficient systems that can handle the demands of modern e-business environments. Businesses may be able to better manage the challenges of blockchain adoption while maintaining security and compliance by creating standardized frameworks and clear regulations. Furthermore, spreading awareness of the benefits and capabilities of blockchain technology can reduce opposition to change and promote broader acceptance. Blockchain technology provides a revolutionary path to digital marketing and e-business, allowing for increased operational efficiency, security and transparency. Blockchain technology can become a critical tool for the future of digital business by redefining the principles of trust and transparency in digital ecosystems by overcoming existing obstacles and leveraging its integration with cutting-edge technologies.

1. **Recommendations**

1-Encouraging multidisciplinary collaboration

* Bring in marketing experts, business strategists, and computer scientists.
* Use a diverse set of knowledge to efficiently address blockchain integration challenges.

2-Implementation of educational projects:

* Providing experts and interested parties with the information and capabilities they need to
* adopt blockchain technology and encourage knowledge about the uses and benefits of blockchain technology.

3-Create scalable, energy-efficient architectures:

* Pay special attention to technologies such as sharding and layer 2 solutions.
* Overcome current limitations related to performance and scalability.

4-Clearly define regulatory frameworks:

* Governments and regulators need to put in place regulations that encourage innovation and compliance.
* Answer questions about consumer protection, fraud prevention, and data privacy.

5-Integrating the latest technologies:

* Integrating blockchain with IoT and AI.
* Enhancing customer engagement, predictive analytics, and operational efficiency.

6-Prioritizing user-centered designs:

* Taking user needs into account when designing applications such as fraud protection systems and loyalty programs.
* Establishing credibility and promoting broad acceptance.

7-Enhancing institutional support and funding:

* Encouraging real-world case studies and empirical research.
* Verifying theoretical benefits and encouraging broader implementation in e-business environments.

8-Putting ethics, innovation, and collaboration first:

* Emphasizing the importance of ethical issues in blockchain technology creation.
* Fostering innovation through cross-industry collaboration.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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