

Optimizing Smart Contracts and Blockchain for Sustainable Digital Fashionpreneurship

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ABSTRACT

The digital fashion industry is undergoing a major transformation with the integration of technologies such as blockchain and smart contracts, which offer solutions to key challenges such as product authenticity, intellectual property protection, and supply chain efficiency. **This research focuses** on the application of blockchain technology and smart contracts in digital fashionpreneurship, with the aim of increasing transaction efficiency, product security, and business sustainability. **Method used in this study** is a quantitative approach with a structural model based on Partial Least Squares Structural Equation Modeling (PLS-SEM) to test the influence between smart contract adoption, digital transaction efficiency, product security, and fashionpreneurship sustainability. Data were collected from digital fashion actors involved in the blockchain-based ecosystem. **Research result shows** that the adoption of smart contracts has a positive effect on transaction efficiency and product security. In addition, blockchain has been shown to increase supply chain transparency that supports the sustainability of digital fashion businesses. Although this technology faces technical challenges such as high transaction speed and costs, solutions such as layer-2 technology can improve blockchain performance. **The conclusion blockchain and smart contract technology** can be an effective solution in increasing efficiency, security, and sustainability in the digital fashion industry. Although there are technical challenges that need to be overcome, the application of this technology has great potential to create a more environmentally friendly and transparent digital fashion ecosystem.

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1. INTRODUCTION

The development of digital technologies has brought a major transformation to the global fashion industry, particularly with the rise of digital fashionpreneurship [1]. This not only involves online fashion

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businesses but also integrates cutting-edge technologies to create, market, and distribute fashion products in both physical and digital forms. Within this ecosystem, challenges such as product authenticity, intellectual property protection, supply chain efficiency, and business transparency have become increasingly critical issues [2]. Blockchain technology has emerged as a potential solution to address these challenges. Its decentralized, transparent, and immutable nature makes it ideal for supporting a more trustworthy and sustainable digital fashion ecosystem [3].

One of the most promising innovations enabled by blockchain is smart contracts, which are digital agreements automatically executed based on predefined conditions [4]. In digital fashion, smart contracts can automate various processes, such as royalty payments, design ownership tracking, and product authenticity validation without the need for intermediaries [5]. Despite its potential, the implementation of blockchain in the fashion industry faces technical challenges, particularly concerning system performance, including transaction speed, high gas fees, and scalability issues [6]. Therefore, optimizing blockchain performance is crucial to overcome these barriers.

This study aims to explore how smart contracts and blockchain performance optimization can enhance innovation and sustainability in digital fashionpreneurship [7]. By investigating the integration of these technologies into digital fashion business practices, this research seeks to offer new insights for industry stakeholders, researchers, and technology developers to create a more inclusive, efficient, and environmentally friendly fashion ecosystem [8]. Furthermore, this paper explores the broader applicability of blockchain in other industries, such as supply chain management in logistics and healthcare, which can further expand the potential impact of these technologies [9].

The research contributes directly to the achievement of the United Nations Sustainable Development Goals (SDGs), especially SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production). Through the adoption of blockchain technology and smart contracts, this study supports the development of resilient and innovative infrastructures within the digital fashion industry (SDG 9), while also fostering responsible production practices, transparency, and traceability across fashion supply chains (SDG 12). By reducing dependency on physical resources through digital assets such as NFTs and enabling verifiable supply chain data, these technologies offer scalable solutions to improve environmental accountability and reduce industrial waste key aspects of sustainable fashion.

2. LITERATURE REVIEW

Digital fashionpreneurship represents a growing sector in the fashion industry where digital technologies are leveraged to create, market, and distribute products [10]. In this ecosystem, fashionpreneurs, who are independent designers and business owners, utilize digital platforms like e-commerce, social media, augmented reality (AR), and non-fungible tokens (NFTs) to compete in the global market [11]. Digital fashionpreneurship offers substantial opportunities for independent designers, but challenges such as design plagiarism, difficulties in tracking product distribution, and lack of transparency persist, hindering industry growth [12].

Blockchain technology has emerged as a transformative solution to these challenges. By providing a decentralized, transparent, and immutable digital ledger, blockchain ensures the authenticity of products, enhances intellectual property protection, and fosters trust throughout the supply chain [13]. Notably, blockchain enables product origin tracking, verification of goods authenticity, and the creation of new business models around digital assets like NFTs. Blockchain technology can enhance consumer trust and business efficiency by offering a transparent and auditable system. Platforms like LUKSO and VeChain have successfully integrated blockchain to improve the fashion supply chain from design to delivery, showcasing its practical applications [14].

One of the most transformative innovations within blockchain technology is the implementation of smart contracts self executing digital agreements that automatically carry out the terms of a contract once pre-determined conditions are met [15]. In the context of the fashion industry, these smart contracts significantly streamline and secure a range of critical processes, including automated royalty payments to designers, real time verification of design ownership, issuance of digital licenses, and facilitation of transparent business collaborations. Smart contracts not only minimize operational costs by removing the need for intermediaries but also reduce the potential for fraud through transparent and immutable contract execution mechanisms [16].

Moreover, the utility of blockchain extends far beyond the realm of fashion. Its application is increasingly being explored in various sectors such as logistics, supply chain management, and healthcare where

secure, traceable, and tamper proof data is critical [17]. In logistics and supply chains, for instance, blockchain can provide end-to-end visibility and real time tracking of goods, thereby improving accountability and reducing delays. In healthcare, it can ensure the integrity of patient records, streamline administrative processes, and enhance data sharing with privacy safeguards [18]. These broader interdisciplinary applications not only highlight blockchain's adaptability and scalability but also reinforce its strategic importance as a foundational technology capable of driving innovation, trust, and efficiency across multiple industries [19].

The Figure 1 above illustrates the flow or process of using smart contracts and blockchain in the digital fashion industry. Here is an explanation of each part of the flow:

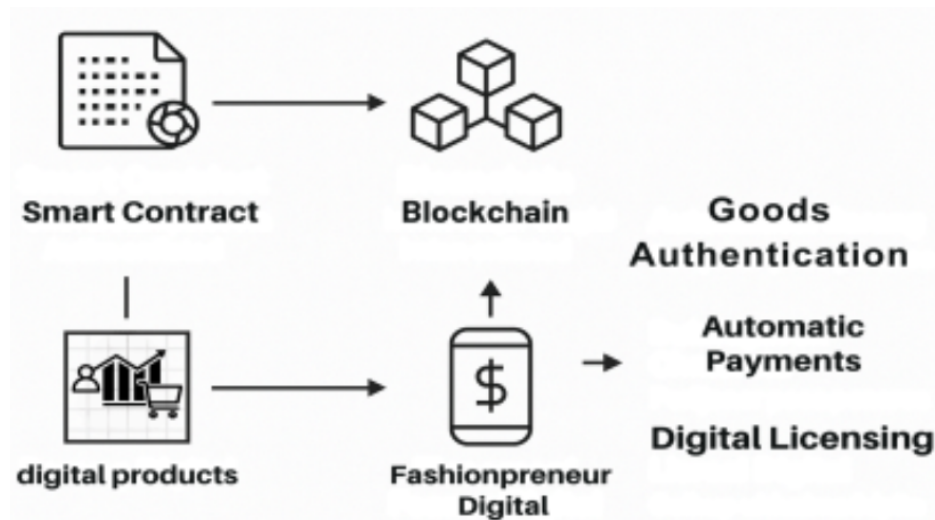


Figure 1. Blockchain and Smart Contract Workflow in Digital Fashionpreneurship

Figure 1 illustrates the integration of smart contracts and blockchain technology in the digital fashion ecosystem, where smart contracts serve to authenticate and automate digital transactions—such as verifying ownership or executing agreements without third-party involvement while blockchain functions as an immutable, decentralized ledger that transparently and securely records every transaction [20]. This process supports the verification and tracking of digital fashion goods, such as designs or products, by ensuring their authenticity and accountable ownership. As a result, fashionpreneurs can efficiently manage transactions and digital ownership, benefiting from a system that enhances trust, security, and transparency in running their digital fashion businesses [21].

Goods Authentication, Automatic Payments, and Digital Licensing This figure also highlights the key features of smart contracts in the digital fashion ecosystem, such as product authentication, automated payments, and digital licensing for digital fashion products, ensuring that all transactions are carried out securely and efficiently [22]. Overall, this figure illustrates how smart contract and blockchain technologies play a vital role in enhancing security, transparency and sustainability in the digital fashion world, by providing solutions to challenges such as product authenticity and supply chain transparency. Despite its promise, the application of blockchain technology in the fashion industry faces a number of complex technical challenges, especially in terms of system performance. Some of the main obstacles include low transaction speed, high transaction costs, and limitations in terms of network scalability [23]. Therefore, blockchain performance optimization strategies are needed, such as the use of layer 2 technology (for example Optimistic Rollups and zk-Rollups) to increase transaction processing capacity. In addition, the implementation of more efficient consensus algorithms such as Proof of Stake (PoS) and Delegated Proof of Stake (DPoS) can reduce energy consumption and speed up transaction confirmation. Sharding techniques and interoperability between blockchains are also relevant approaches to increasing scalability. The combination of layer 2 technology and efficient smart contracts can increase transaction speeds by up to five times and significantly reduce transaction costs in the context of fashion NFTs [24].

Furthermore, blockchain-based innovations also drive sustainability aspects in the fashion industry [25]. This industry is known as one of the largest contributors of waste globally, so the integration of technol-

ogy that supports transparency and a circular economy is essential. Blockchain enables detailed and publicly verifiable supply chain tracking, so consumers can clearly trace the origin of raw materials and production processes [26]. In addition, the development of digital fashion such as NFT-based clothing can also reduce dependence on physical production and textile waste. The McKinsey report (2023) states that brands that implement blockchain for supply chain transparency experience a significant increase in consumer loyalty, because they are considered more socially and environmentally responsible [27].

3. RESEARCH METHODS

This research employs a quantitative explanatory design that aims to analyze and explain the causal relationships among several core variables related to the implementation of smart contract technology and the optimization of blockchain performance in the digital fashionpreneurship sector [28]. The selection of a quantitative explanatory approach is well-aligned with the study's objective of testing predefined hypotheses and determining the strength and direction of influence among variables. To analyze the data, the study utilizes the Partial Least Squares Structural Equation Modeling (PLS-SEM) technique, which is appropriate for complex research models involving multiple latent variables and indicators. The analysis is conducted using SmartPLS 3.0 software, known for its robustness in estimating path models with reflective constructs and small to medium sample sizes [29].

The target population for this study includes individuals who are actively involved in the digital fashion ecosystem, particularly digital fashionpreneurs and consumers who have experience engaging with blockchain-enabled fashion platforms. To ensure the relevance and reliability of the responses, the study uses purposive sampling, a non-probability sampling method that selects respondents based on specific inclusion criteria [30]. Participants are required to have previously interacted with or utilized blockchain based digital fashion platforms and to possess at least a fundamental understanding of how digital technologies—such as smart contracts, NFTs, and decentralized ledgers are integrated into the fashion industry. This ensures that the respondents have contextual knowledge and are able to provide informed responses regarding the impact of these technologies [31].

The study incorporates five primary latent variables, each operationalized through multiple perception-based indicators measured on a 5-point Likert scale, where 1 indicates "strongly disagree" and 5 indicates "strongly agree." The variables are as follows:

- Smart Contract Adoption (ASC) refers to the extent to which smart contracts are integrated into the digital operations of fashionpreneurs [32]. Indicators for this variable include the use of smart contracts to facilitate automatic digital transactions, perceptions of reduced reliance on intermediaries, and improved transactional reliability.
- Efficiency of Digital Transactions (ETD) measures perceived improvements in digital transaction processes resulting from the adoption of blockchain technology. This includes enhancements in transaction speed, reduced processing time, cost savings, and overall convenience in conducting fashion-related digital exchanges [33].
- Product Safety and Authenticity (KKP) assesses user trust in blockchain systems to ensure the originality, integrity, and legal ownership of digital fashion products [34]. Indicators include perceptions of digital design protection, data security, traceability, and the verifiability of product authenticity using blockchain records.
- Fashionpreneurship Sustainability (KF) evaluates the extent to which fashion businesses apply principles of sustainability, encompassing economic viability, social responsibility, and environmental awareness [35]. Key indicators include the use of technology to reduce digital and physical waste, transparent supply chain practices, and alignment with sustainability goals such as the SDGs.

Blockchain Performance (PB) reflects respondents' perceptions of the technical reliability and effectiveness of blockchain systems in supporting digital fashion business operations. This includes key aspects such as transaction speed, cost efficiency, network scalability, and energy consumption [36]. A high level of

blockchain performance indicates that the system can process transactions quickly and affordably, handle increased usage without performance issues, and operate in an energy-efficient manner, all of which are essential for enabling smooth, scalable, and sustainable digital fashion activities [37].

These five interconnected variables are modeled within a PLS-SEM framework to test both direct and indirect relationships. The structural model is designed not only to analyze the isolated effects of smart contract adoption and blockchain performance on key digital fashion business outcomes but also to examine the mediating roles of transaction efficiency and product authenticity in shaping the sustainability of digital fashionpreneurship [38]. This dual approach allows for a comprehensive understanding of how these variables interact and influence each other, providing valuable insights into the complexities of blockchain integration in digital fashion. By incorporating both direct and mediated pathways, the study highlights how blockchain technology and smart contracts contribute to improving operational efficiency, securing digital products, and fostering long-term business sustainability. The use of this modeling approach enables the study to offer empirical insights into the role of emerging technologies in driving innovation, achieving operational excellence, and promoting responsible business practices within the digital fashion ecosystem, ultimately facilitating its growth and competitiveness in the global market [39].

Table 1. Definition of Variables

Code	Variables	Short Definition
ASC	Smart Contract Adoption	The level of implementation of automated digital contracts in the digital fashion ecosystem
PB	Performa Blockchain	Perceptions of the speed, cost, and scalability of blockchain systems.
ETD	Efficiency of digital transactions	The level of transaction efficiency achieved by implementing blockchain technology.
KKP	Product safety and authenticity	Perceptions of rights protection, authentication, and product tracking.
KF	Fashionpreneurship sustainability	Efforts to develop digital fashion in an environmentally friendly and responsible manner.

Table 1 presents a concise summary of the five key latent variables used in this study to evaluate the role of blockchain and smart contracts in digital fashionpreneurship. Smart Contract Adoption (ASC) measures how digital contracts are used to automate transactions without third-party involvement [40]. Blockchain Performance (PB) captures user perceptions of speed, cost, and scalability. Efficiency of Digital Transactions (ETD) assesses how blockchain enhances transaction speed, convenience, and cost-effectiveness [41]. Product Safety and Authenticity (KKP) reflects trust in the system's ability to protect digital assets and verify authenticity. Lastly, Fashionpreneurship Sustainability (KF) evaluates sustainable practices such as waste reduction and supply chain transparency. These variables, as shown in Table 1, form the foundation for analyzing how technology adoption influences efficiency, security, and sustainability in the digital fashion industry [42].

Table 2. Research Hypotheses

Code	Hypothesis
H1	The adoption of smart contracts has a positive impact on the efficiency of digital transactions.
H2	Blockchain performance has a positive impact on the efficiency of digital transactions.
H3	Smart contract adoption has a positive impact on product security and authenticity.
H4	Blockchain performance has a positive impact on product security and authenticity.
H5	The efficiency of digital transactions has a positive impact on the sustainability of fashionpreneurship.
H6	Product safety and authenticity have a positive impact on the sustainability of fashionpreneurship.
H7	Transaction efficiency and product security simultaneously mediate the influence of technology adoption on fashionpreneurship sustainability.

As outlined in Table 2, this study formulates seven hypotheses that explore the relationships among key variables within the blockchain-based digital fashionpreneurship framework [43].

- The first hypothesis (H1) posits that the adoption of smart contracts positively influences the efficiency of digital transactions, as these contracts automate execution processes without intermediaries, thereby accelerating transactions and reducing associated costs [44].
- The second hypothesis (H2) further suggests that smart contract adoption enhances product security and authenticity by enabling transparent, automated verification of ownership and intellectual property rights, which in turn fosters greater trust in the legitimacy of digital fashion products [45].
- The third hypothesis (H3) states that blockchain performance has a positive effect on the efficiency of digital transactions. When blockchain has high performance in terms of speed, cost, and scalability, transactions can be carried out faster and more efficiently [46].
- The fourth hypothesis (H4) states that blockchain performance has a positive effect on product security and authenticity, because this technology is able to record every transaction permanently and cannot be modified, making it easier to track the origin of the product and guarantee the authenticity of the data [47].
- The fifth hypothesis (H5) states that digital transaction efficiency has a positive effect on the sustainability of fashionpreneurship. An efficient transaction process will increase user convenience, reduce operational costs, and support sustainable business growth [48].
- The sixth hypothesis (H6) states that product security and authenticity also have a positive impact on the sustainability of digital fashion businesses. When products are believed to be authentic and safe, both designers and consumers will feel more trusting and loyal to the digital ecosystem [49].
- Finally, the seventh hypothesis (H7) states that digital transaction efficiency and product security jointly mediate the effect of technology adoption on fashionpreneurship sustainability [50].

This means that technologies such as smart contracts and blockchain not only have a direct impact on business sustainability, but also through increased efficiency and security resulting from the implementation of these technologies [51]

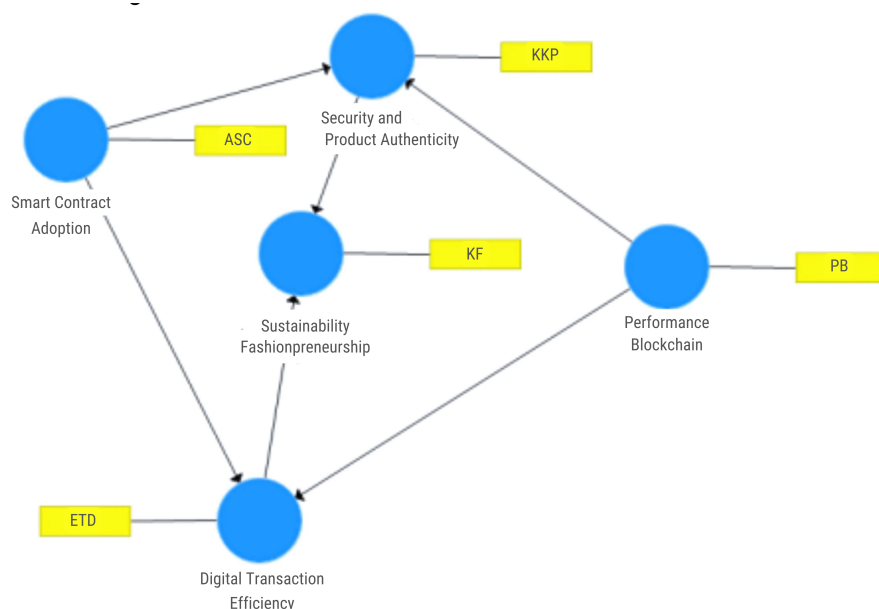


Figure 2. Structural Model of Blockchain-Based Digital Fashionpreneurship

As illustrated in Figure 2, the structural model generated through SmartPLS demonstrates the directional relationships among the latent variables in this study. The model reveals that Smart Contract Adoption (ASC) has a direct influence on both Product Security and Authenticity (KKP) and Digital Transaction Efficiency (ETD). These two variables, functioning as mediators, subsequently contribute to Fashionpreneurship

Sustainability (KF), which serves as the main dependent variable [52]. Additionally, Blockchain Performance (PB) is shown to significantly affect both KKP and ETD, indicating that the perceived technical quality of blockchain systems such as speed, cost, and scalability also shapes user trust and transaction efficiency. The pathway relationships in Figure 2 confirm that the impact of blockchain and smart contracts extends beyond direct effects, also operating through mediated pathways that collectively enhance the sustainability of digital fashion businesses. This structural model offers a robust conceptual framework for understanding how decentralized digital transformation drives innovation and long-term sustainability in the fashionpreneur ecosystem.

4. RESULTS AND DISCUSSION

Building upon the conceptual framework and hypotheses presented in the previous section, this study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to test the relationships between smart contract adoption, blockchain performance, and key outcomes in digital fashionpreneurship. The results validate the significant role of emerging technologies in shaping operational efficiency, product authenticity, and sustainability. This section elaborates on the direct and indirect effects observed in the analysis while providing contextual insights relevant to the fashion industry.

The structural model confirms the hypothesized pathways and offers empirical support for the mediating role of transaction efficiency and product security. These insights are crucial, especially for fashionpreneurs seeking to integrate blockchain and smart contracts not merely as technological tools but as enablers of long-term value. Moreover, the findings provide a foundation for future developments in sustainable fashion innovation, policy alignment, and ecosystem design.

Overall, the results show that while smart contracts and blockchain performance have direct effects on operational and strategic dimensions of digital fashion business, their true value emerges through interconnected pathways. This highlights the need for a holistic approach to technology implementation—one that is grounded in practical outcomes and aligned with environmental, economic, and social goals.

4.1. Smart Contracts and Transaction Efficiency

The adoption of smart contracts demonstrated a strong positive effect on digital transaction efficiency. Respondents indicated that smart contracts reduce reliance on intermediaries by automating payments, licensing, and product delivery confirmations. This automation increases transaction speed, reduces costs, and minimizes the risk of human error. These improvements are especially valuable in fast-paced digital marketplaces where user experience and convenience are key differentiators.

In addition to operational gains, smart contracts contribute to business scalability. By simplifying processes and increasing reliability, they enable fashionpreneurs to handle higher volumes of transactions without proportionally increasing administrative burden. This reinforces the idea that digital innovation is not only about introducing new tools but also about creating scalable systems that support long-term growth. The positive user perception of smart contracts in this study highlights their role in enhancing business agility.

These findings echo previous literature asserting that smart contracts can serve as key infrastructure in digital commerce ecosystems. In the context of fashion, where design replication and transactional friction are common, smart contracts provide automated enforcement of business rules. Thus, the results affirm that their implementation not only boosts efficiency but also improves customer satisfaction and trust.

4.2. Blockchain Performance and Product Authenticity

Blockchain performance was found to significantly influence the perceived security and authenticity of digital fashion products. Respondents emphasized the importance of a fast, scalable, and cost-effective blockchain system in protecting product originality and verifying ownership. A high-performing blockchain provides a transparent and tamper-proof ledger that helps prevent counterfeiting, which is a persistent problem in the fashion industry.

Moreover, the study found that users associate better blockchain performance with a stronger sense of trust in the digital transaction process. When systems function smoothly and record data reliably, both sellers and buyers feel more secure engaging in the exchange of high-value digital fashion items. This trust is not only technical but also psychological, reinforcing long-term engagement with the platform or marketplace.

In this regard, blockchain acts as more than a back-end system—it becomes a visible trust enabler. Whether for NFT garments or digital design rights, blockchain's immutable data structure enhances transparency and accountability. The findings support earlier research suggesting that blockchain's performance

characteristics are vital for ensuring both operational success and user adoption in fashion technology ecosystems.

4.3. Mediation Effects and Sustainability Pathways

The results also validate that digital transaction efficiency and product security act as significant mediators between technology adoption (ASC and PB) and fashionpreneurship sustainability. These mediators translate technical capabilities into business impact by enhancing trust, convenience, and eco-efficiency. The model shows that indirect effects via ETD and KKP are as crucial as direct paths in achieving sustainable outcomes.

Efficient transactions support sustainability by reducing time, energy, and resource consumption. Automated smart contracts minimize paperwork, platform redundancy, and wasteful steps in supply chain processes. On the other hand, product authenticity contributes to sustainability by deterring the spread of knock-offs and incentivizing consumers to invest in verified, high-quality digital fashion assets.

These pathways align well with Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production). Fashionpreneurs who adopt blockchain and smart contracts are not just improving their bottom lines but are actively participating in shaping more transparent and responsible digital economies. The mediation results reinforce the notion that sustainability is achieved through operational excellence powered by ethical technologies.

4.4. Implementation Challenges and Technical Solutions

Despite the promising findings, this study also identified several challenges that hinder the broader implementation of blockchain in digital fashion. Among the most pressing issues are high transaction fees, limited scalability, and slow confirmation speeds, particularly on networks that use Proof of Work consensus. These limitations disproportionately affect small to mid-sized fashion businesses with constrained resources.

To address these technical issues, the study highlights the need for adopting Layer-2 scaling solutions such as zk-Rollups and Optimistic Rollups. These off-chain technologies reduce congestion on the main chain and significantly lower gas costs, making blockchain platforms more accessible and economically viable. In addition, transitioning to more energy-efficient consensus mechanisms like Proof of Stake (PoS) can improve performance and sustainability simultaneously.

Beyond technical fixes, there is also a need for better education and onboarding strategies. Many fashionpreneurs still lack familiarity with blockchain concepts and tools, which creates a psychological barrier to entry. As such, developers and policymakers should work together to simplify user interfaces and promote digital literacy, ensuring that innovation in this space is inclusive and widely adopted.

4.5. Strategic Implications and Future Research

These findings offer critical managerial insights for digital fashionpreneurs and technology developers. Businesses that strategically adopt smart contracts and high-performing blockchain platforms are likely to achieve superior efficiency, stronger brand trust, and more sustainable operations. Moreover, transparency enabled by blockchain can become a powerful marketing asset in a consumer landscape that values authenticity and accountability.

For developers and platform providers, the results emphasize the importance of designing systems that balance performance, cost, and usability. Blockchain technologies must move beyond experimentation and pilot phases into mature, user-friendly infrastructures. Collaboration between fashion brands, technologists, and regulators will be essential to establish standards that ensure interoperability and long-term adoption.

Future research can build on these results by exploring behavioral aspects of blockchain adoption in fashion, comparative studies between blockchain platforms (e.g., Ethereum vs. Solana), and lifecycle assessments of digital versus physical fashion products. This would deepen our understanding of how technological choices intersect with business models and environmental outcomes.

5. MANAGERIAL IMPLICATION

This study provides valuable insights for digital fashionpreneurs and stakeholders in the blockchain ecosystem. The findings suggest that the adoption of smart contracts and the optimization of blockchain performance can significantly enhance operational efficiency, security, and sustainability in digital fashion businesses. Below are several key managerial implications based on the study's results.

5.1. Enhancing Operational Efficiency

The positive impact of Smart Contract Adoption (ASC) on Digital Transaction Efficiency (ETD) highlights the importance of adopting smart contracts to streamline business operations. Fashionpreneurs should consider integrating smart contract technology into their platforms to automate transactions and reduce reliance on intermediaries. By doing so, businesses can not only improve transaction speeds and reduce costs but also enhance the overall customer experience by ensuring quicker, more convenient transactions. Fashion businesses that adopt smart contracts will likely have a competitive edge in the fast-paced digital fashion market.

5.2. Improving Product Security and Authenticity

Blockchain Performance (PB) plays a crucial role in enhancing both transaction efficiency and product security (KKP). Fashionpreneurs should prioritize the adoption of high-performing blockchain systems that provide transparent, immutable records of transactions. This will ensure the authenticity of digital products, protect intellectual property, and build trust with consumers. Given the high risks of counterfeit products in the fashion industry, integrating blockchain to verify product authenticity is vital for gaining consumer confidence and loyalty. Additionally, securing digital designs and intellectual property through blockchain can help reduce fraud and design theft.

5.3. Driving Sustainability in Digital Fashion

The study's findings emphasize that both transaction efficiency and product security contribute to Fashionpreneurship Sustainability (KF). Fashion businesses can benefit from adopting blockchain technology to promote environmentally and socially responsible practices, such as improving supply chain transparency and reducing digital waste. Managers should explore how blockchain can support sustainability initiatives, such as traceable supply chains and NFT-based business models that reduce the need for physical production. Integrating these practices not only aligns with consumer demand for transparency but also helps fashion businesses meet their corporate social responsibility goals and reduce their environmental impact.

5.4. Addressing Technical Challenges

Despite the benefits, the study identifies transaction costs and processing speeds as ongoing challenges for blockchain adoption. Fashionpreneurs should be aware of these barriers, especially if they operate on smaller budgets. It is recommended that businesses explore layer-2 solutions, such as zk-Rollups and Optimistic Rollups, which can help reduce transaction fees and improve blockchain performance. Additionally, adopting Proof of Stake (PoS) and other efficient consensus mechanisms may enhance transaction speeds and lower energy consumption. Managers should stay updated on the latest blockchain innovations and select platforms that balance performance, cost, and scalability.

6. CONCLUSION

This study demonstrates that the integration of blockchain technology and smart contracts can significantly improve key aspects of digital fashionpreneurship, including transaction efficiency, product security, and business sustainability. The adoption of smart contracts has a direct positive effect on transaction speed, cost reduction, and overall convenience by automating processes and eliminating intermediaries. Similarly, blockchain performance enhances transaction efficiency and product security, providing immutable and transparent records that protect digital products, ensuring their authenticity and intellectual property rights. These improvements contribute to smoother operations and increased consumer trust, essential for thriving in the fast-evolving digital fashion market.

However, despite the numerous benefits, the study identifies significant technical challenges, particularly in terms of transaction costs and processing speeds, which can hinder the adoption of blockchain, especially for smaller businesses. Solutions such as layer-2 technologies and efficient consensus mechanisms like Proof of Stake (PoS) offer promising ways to address these issues by improving performance and reducing costs. As blockchain technology continues to evolve, fashion businesses must adapt to these innovations to maximize the potential of blockchain in enhancing efficiency, security, and scalability.

Looking forward, blockchain technology has the potential to revolutionize the digital fashion industry, fostering greater sustainability, transparency, and security within the fashion supply chain. It is crucial for fashionpreneurs to integrate blockchain into their business practices to remain competitive and align with growing consumer demand for ethically produced and sustainably sourced fashion. Future research can explore

the environmental impacts of blockchain adoption and further investigate its applications across industries like logistics and healthcare. By leveraging blockchain, digital fashion businesses can create a more innovative, transparent, and environmentally responsible fashion ecosystem.

7. DECLARATIONS

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Conceptualization: SS, RS, and MK; Methodology: AK; Software: RS; Validation: MK and SS; Formal Analysis: SS and RE; Investigation: RS; Resources: SS; Data Curation: RE; Writing Original Draft Preparation: RS and AK; Writing Review and Editing: MK; Visualization: RE; All authors, SS, RS, SK, MK, and RE, have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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