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Examining Readiness to Buy Fashion Products Authenticated with Blockchain

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Abstract: The fashion industry is undergoing significant transformation through blockchain technology, which enhances product traceability, authenticity, and transactional transparency. This study explores blockchain's potential to revolutionize the fashion supply chain by enabling detailed monitoring from design and manufacturing to certification, quality control, storage, transportation, and delivery. To assess customers' readiness to adopt these authenticated products, an innovative model for fashion product traceability and authenticity based on blockchain was proposed. Since the adoption of blockchain models relies on widespread user involvement, it is crucial to examine the factors that motivate individuals to take part. To this end, an acceptance study was conducted using the modified UTAUT2 (Unified Theory of Acceptance and Use of Technology) framework, with data analyzed using SMART PLS software. The results indicate that the proposed blockchain model can improve transparency, authenticity, and customer trust in fashion products. Furthermore, the findings identify expected effort, perceived efficiency, and social influence as key factors influencing blockchain adoption in the fashion industry. These insights show the importance of targeted education and customer engagement strategies for successful implementations of blockchain technology in the fashion industry.

Keywords: blockchain; fashion industry; supply chain traceability; product authenticity; UTAUT2

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1. Introduction

The recent demand for transparency and authenticity is driving evolution within the fashion industry. Consumers seek confidence in the origins and ethical production of their garments. Traditional supply chains, which are often opaque and fragmented, struggle to provide detailed information about business transactions, making it difficult for consumers to verify the authenticity of purchased products.

Research by the authors of [1] demonstrates that blockchain technology offers a solution to these new challenges faced by the fashion industry supply chains. It enables real-time tracking of transactions and product lifecycle from raw materials to finished goods, assuring consumers of product authenticity and ethical practices. This transparency can ensure the authenticity of products, preventing counterfeiting, and ethical production methods, which have so far been a significant challenge in the fashion industry. Blockchain technology has the potential to transform the fashion industry by ensuring transparency, security, and product tracking, benefiting all participants, from manufacturers to consumers [2]. By creating a decentralized ledger that records every transaction or product movement in an immutable and transparent fashion, blockchain technology ensures that each product's journey is traceable and verifiable [3]. According to [4], blockchain technology can enhance consumer trust, as it provides a reliable source of information on the product origins, manufacturing processes, and the ethical credentials of the supply chain. Furthermore, blockchain's built-in security features prevent tampering and fraud, ensuring the integrity of the product data from start to finish.

Blockchain technology has emerged as a transformative force in supply chain management, offering enhanced transparency, security, and traceability. Previous studies in other industries, such as agri-food, have explored consumers' willingness to adopt blockchain technology, particularly with a focus on traceability and product authenticity, such as in the ancient wheat sector, using the technology acceptance model (TAM) [5], and in verifying the authenticity of organic coffee [6]. These specific studies were selected because they apply the TAM specifically in the context of product authenticity and supply chain transparency, challenges that the fashion industry also faces, such as provenance verification and ethical sourcing. The TAM, originally proposed by [7], has been widely adopted to explain users' behavioral intention to adopt new technologies across various domains. Notable extensions include [8], who applied the TAM to electronic transaction systems, and [9], who incorporated flow theory to analyze online consumer behavior. These works illustrate the TAM's broad applicability in studying perceived usefulness, ease of use, and trust in digital contexts. In this research, the TAM is particularly relevant because it helps capture consumers' willingness to engage with blockchain-based solutions that promote transparency and authenticity in the fashion supply chain. In this regard, the studies by [5,6] are especially insightful, as they contextualize the TAM in sectors that also rely on product authenticity and supply chain integrity, providing a strong conceptual basis for transferring these findings to the relatively underexplored fashion industry.

Despite the significant transformative potential that blockchain holds for the textile and fashion industry, particularly in improving supply chain transparency, traceability, and sustainability [10,11], there is a notable lack of empirical research and systematic analysis on the adoption of blockchain in fashion, especially regarding consumer engagement and implementation challenges [12]. Furthermore, the real-world application of blockchain in the fashion and textile sector remains limited and underexplored [3], even though this technology can offer promising solutions for issues such as counterfeiting, intellectual property protection, and trust-building. Trust is a highly important issue in the acceptance of blockchain systems because customers have to be certain that the data in the blockchain, such as origin of the product, certification, or ethical practices, are safe, non-modifiable, and authenticated by reliable authorities. Blockchain's decentralization and transparency build trust by offering an unalterable audit trail and data integrity that is necessary in industries, such as fashion, where authenticity of the product and ethical origin are being required by consumers with greater frequency [13,14].

Blockchain technology has not been the sole innovation that brings transformation to supply chain management. There are other advanced technologies, such as cloud computing, big data analytics, artificial intelligence (AI), and the internet of things (IoT) that, in synergy with blockchain, bring greater efficiency, security, and transparency to supply chains and allow better automation, analysis, and process optimization.

Cloud computing allows decentralized and scalable processing of data, which is quintessential in the case of large and complex supply chains. Integration with blockchain makes cloud computing provide companies with a secure and efficient infrastructure to store and share data among supply chain participants [15]. The integration of blockchain with big data analytics allows the analysis of immutable data from diverse sources, thereby enhancing the accuracy of predictions used for strategic decision-making [16]. By ensuring data integrity and preventing manipulation or unauthorized changes, blockchain technology strengthens the overall reliability of information within the supply chain.

Artificial intelligence brings advanced automation and intelligent decision-making capabilities to supply chain management. Integrated with blockchain, AI analyzes big data and optimizes automatically selected key supply chain processes such as inventory forecasting and risk management [17]. The combination of smart contracts on the blockchain with AI algorithms allows the autonomous execution of business processes without the need for intermediaries [18]. The integration of AI and blockchain offers significant potential to enhance supply chain operations by enabling real-time demand forecasting, improving transparency, and supporting automated product authentication—benefits that can be particularly valuable in the fashion industry [19,20].

Studies such as [21] have shown that with the integration of IoT and blockchain technologies, new opportunities can be created to improve supply chain management. IoT devices provide real-time data collection and monitoring throughout the supply chain, from production to delivery [22]. When integrated with blockchain, these data points become part of a secure, immutable record, providing a single source of truth for all transactions and movements [23]. By allowing consumers access to the records kept in the blockchain, their trust in the authenticity and security of fashion products can be significantly enhanced [24]. Consumers can be assured of receiving genuine products while having their private information protected, fostering a reliable relationship between brands and consumers [25]. The integration of IoT and blockchain technologies has been shown to enhance real-time product tracking, transparency, and operational efficiency across supply chains that are highly relevant and transferable to the fashion industry [26].

Blockchain adoption in fashion faces several challenges, including high implementation costs, technological complexity, and limited consumer awareness [27]. A key determinant of adoption is consumer trust, as blockchain's immutability and transparency can reinforce brand credibility and product legitimacy [28]. However, skepticism about blockchain's complexity, data security, and usability persists, which may discourage mainstream consumers from engaging with blockchain-enabled platforms [29]. Security in blockchain systems relies on cryptographic hashing and decentralized consensus algorithms, with each block containing a 256-bit hash of the previous block, which prevents subsequent modifications unless a majority of the network's nodes agree [30]. In the context of supply chain management in the fashion industry, blockchain networks are often permissioned, meaning that all participants are authenticated, and that consensus is achieved through specific protocols, which further guarantees data authenticity and integrity. Additionally, digital signatures and transaction encryption ensure the confidentiality of business information exchanged between suppliers, manufacturers, and distributors, thereby strengthening the overall resilience of the supply chain against tampering and unauthorized interventions [31]. While some consumers appreciate blockchain's ability to provide verifiable information about product provenance, others may struggle to see its relevance in their purchasing decisions [32]. Understanding these behavioral and perceptual barriers is essential for ensuring successful blockchain integration in the fashion industry.

In this paper, an innovative model for fashion product traceability and authenticity based on blockchain is presented. The model describes the roles and interactions of various participants in the fashion industry supply chain, including manufacturers, suppliers, retailers, and consumers. The goal of the model is to achieve comprehensive product traceability and authenticity. However, the difficulty lies in ensuring that the entire supply chain is integrated into the blockchain while ensuring availability and transparency of data to all participants. The proposed model provides a detailed insight into all participants in the fashion industry supply chain and explains their interactions and business transactions within the blockchain.

The first step in implementing any model is conducting an acceptance study. For the proposed model, an acceptance study was conducted using a modified UTAUT2 to evaluate customers' readiness to purchase fashion products authenticated using blockchain. This research proposes an enhanced adoption model, incorporating key constructs from UTAUT2 and extending it with trust and risk tolerance as additional factors shaping blockchain adoption in fashion retail. This model offers a more tailored framework for understanding how blockchain solutions can be optimized for consumer engagement. Specifically, variables such as effort expectancy, performance expectancy, trust, and price value have been identified as critical factors in other technology adoption studies, yet their role in blockchain-based fashion retail has not been systematically examined [27]. While prior literature has explored blockchain's potential for anti-counterfeiting and sustainability, our findings emphasize the need for user-centric applications, targeted awareness campaigns, and strategic trust-building initiatives [12]. The study suggests that brands, policymakers, and technology developers must prioritize accessibility, education, and seamless integration to enhance consumer readiness [28]. Most blockchain-related solutions depend on high levels of user engagement to be financially viable, making acceptance studies crucial.

By extending theoretical models of blockchain adoption and providing practical guidance for industry stakeholders, this research offers a meaningful contribution to both academia and practice. Analyzing the results offers valuable insights into the factors that influence blockchain adoption in the fashion industry. The findings of this research highlight that social influence, perceived ease of use, and efficiency are the most influential factors driving the adoption of blockchain-authenticated fashion products. Low consumer awareness and the insufficiently recognized value of this technology in fashion retail still represent a significant barrier to its wider adoption [11,32]. The results reinforce previous research on technology acceptance models, confirming that effort expectancy and perceived usefulness are critical in influencing consumer behavior [27]. The results of the acceptance study can be used to tailor implementation strategies, ensuring higher user engagement and smoother integration of blockchain technology within the supply chain.

The paper consists of six sections. Section 2 explains the theoretical background of blockchain technology and its application in the fashion industry, where the potential of blockchain in product traceability is thoroughly and clearly examined. Section 3 presents a model for the traceability and authenticity of fashion products based on blockchain. Section 4 examines customers' readiness to purchase fashion products authenticated with blockchain. Section 5 analyzes the survey results on this topic. Finally, Section 6 provides conclusions, theoretical and practical implications and limitations, and opportunities for further research.

2. Blockchain in the Fashion Industry

Blockchain technology has emerged as a transformative force across various industries, including the fashion sector. Its ability to enhance transparency, traceability, and security in supply chain management makes it particularly valuable for fashion brands seeking to build consumer trust and combat counterfeit goods. By utilizing the blockchain, fashion companies can provide customers with verifiable information about the origins, materials, and manufacturing processes of their products [1]. This chapter explores the integration of blockchain technology within the fashion industry, highlighting its potential to modernize traditional practices and foster a more transparent supply chain.

2.1. Blockchain in Fashion Supply Chains

Blockchain technology is transforming various industries by enhancing the security, efficiency, and transparency of data handling and business operations [33]. Unlike conventional systems that rely on centralized databases, blockchain utilizes a decentralized network of computers that collaboratively validate and record transactions. This ensures that all participants can access and trust the data, which is securely distributed across multiple locations [34]. Each block in the blockchain contains transactions or data entries, which, once verified, are time-stamped and linked sequentially in a chain resembling a digital ledger. This ledger is encrypted, safeguarding it against unauthorized alterations and ensuring data integrity [35].

The distributed nature of blockchain eliminates any single point of failure and makes it resistant to cyber-attacks or data corruption [36]. Each participant in the network possesses a copy of the entire ledger, requiring consensus from multiple nodes before a new transaction is added. This consensus mechanism ensures immutability while allowing all entries to be verifiable by all parties. Additionally, blockchain architecture enables the automation of transaction verification and synchronization, streamlining processes that traditionally require significant time and resources [35].

One of blockchain's most valuable applications in fashion supply chains is smart contracts, which automate and enforce agreements between parties without intermediaries. Smart contracts execute operations based on predefined conditions, ensuring that contractual obligations are fulfilled autonomously and securely [37]. By eliminating third parties such as banks and legal representatives, they reduce processing time and costs while enhancing trust and efficiency. Smart contracts offer several advantages in supply chain management. They increase efficiency by reducing manual interventions, enabling faster transaction execution, and minimizing operational delays [38]. Security is also enhanced, as smart contracts are encrypted and immutable once deployed, preventing unauthorized alterations [39]. They allow self-management, giving stakeholders greater control over agreements and eliminating the need for continuous oversight [40]. Another significant benefit is transparency, as smart contracts are recorded on a distributed ledger, allowing all authorized participants to verify contract terms and execution history [41]. This is particularly valuable in the fashion industry, where supply chain transparency is crucial for verifying ethical sourcing and sustainability compliance. Smart contracts help reduce administrative costs by minimizing expenses related to legal documentation and intermediary fees, making them especially beneficial for small businesses [42]. Furthermore, smart contracts are adaptable to evolving regulatory and business requirements, ensuring their long-term usability [37]. Their cryptographic security also helps prevent fraud, as all transactions and contract terms remain immutable and verifiable, reducing the risk of counterfeiting and fraudulent activities [43].

Beyond smart contracts, blockchain technology is revolutionizing supply chain logistics by enabling real-time tracking of materials and products. Traditional logistics systems often lack transparency, making it difficult to trace product origins and verify authenticity [44,45]. Blockchain provides a verifiable source of information by recording transactions immutably, allowing for a decentralized, consensus-driven ledger that ensures supply chain integrity.

A notable blockchain application in fashion supply chains is product traceability, which enables stakeholders to track an item's journey. By scanning a QR code or using an NFC tag linked to the blockchain, consumers and retailers can access verifiable product information, including material origins, manufacturing processes, and distribution history [46]. This level of traceability is particularly valuable for luxury brands seeking to protect their exclusivity and combat counterfeit goods [1].

Blockchain's role in logistics monitoring has also been widely explored. Studies have introduced blockchain-based frameworks that track parcels and maintain immutable transaction records, improving dispute resolution and reducing inefficiencies [47]. Integrating blockchain with electronic data interchange (EDI) unifies data formats and enhances supply chain collaboration, reducing costs and processing time. Furthermore, the integration of blockchain with IoT technology enhances data tracking accuracy by enabling sensor networks to autonomously communicate and update the ledger in real-time, thereby eliminating the need for centralized cloud storage [48,49].

Different blockchain architectures offer varying levels of security and accessibility in supply chain management. Public blockchains, such as Ethereum, allow full transparency by providing a tamper-proof ledger accessible to all participants. These platforms are particularly useful for ensuring ethical sourcing and real-time tracking of materials [50]. On the other hand, private blockchains, such as Hyperledger Fabric and Corda, provide controlled access to authorized participants, making them ideal for businesses that require heightened data security and confidentiality [51]. Hybrid and consortium blockchains balance transparency and confidentiality, enabling selective data sharing between the supply chain stakeholders [52].

A comprehensive blockchain-based model for the fashion supply chain was proposed by [53], ensuring transparent and immutable business transactions among stakeholders. This system enhances security, reduces counterfeit products, and allows customers to verify product origins. Additionally, a dual-token model for blockchain implementation in the garment industry has been proposed to facilitate traceability and economic transactions. An example of this approach is Provenance, a platform that tracks materials from their source to the finished product, reinforcing trust in the supply chain [54].

By integrating blockchain technology into fashion supply chains, companies can enhance efficiency, security, and transparency, ensuring compliance with ethical standards and consumer expectations.

2.2. Tracking Product Authenticity in the Fashion Industry

The fashion industry generates USD 3 trillion and contributes 2% to the global gross domestic product (GDP) [55]. This industry plays a crucial role in the design, production, and sale of clothing and apparel, encompassing various sectors such as the fabrication of raw materials, the production of fashion clothes and garments by designers, commercialization, and marketing communication. It is characterized by short product life cycles, a wide variety of products, unstable and unpredictable demand, and long, inflexible supply processes, which make it a suitable candidate for the implementation of efficient supply chain management practices [56].

By applying blockchain technology, some common issues in the fashion industry can be addressed. As a distributed ledger, blockchain enables a secure and transparent exchange of digital assets without requiring central intermediaries, ensuring transaction accuracy and preventing fraud [57,58]. Moreover, blockchain helps safeguard customer data privacy by reducing the risk of information leakage and data manipulation, reinforcing consumer trust in digital transactions [59–61]. Another benefit of blockchain technology in fashion is its ability to enhance transparency, traceability, and authenticity by enabling e-commerce platforms to allow end-users to track product information throughout its entire lifecycle—from design and production to retail [62,63]. This level of traceability helps verify ethical sourcing practices, ensuring that products meet sustainability and labor standards. The textile industry requires the implementation of traceability to address the challenges of existing information asymmetry and inadequate visibility [12]. Customers often find it difficult to access product data that would enable ethical purchasing or guarantee product authenticity. Furthermore, sharing sensitive information in an insecure environment, with the risk of data manipulation and fear of losing informational advantage, presents a significant challenge [1].

By eliminating intermediaries, reducing administrative overhead, and streamlining operations, blockchain optimizes business processes [64]. Smart contracts automate transactions between multiple parties, reducing paperwork, minimizing errors, and decreasing the time required for contract validation [65]. Additionally, blockchain enhances cost-efficiency for customers by providing secure access to product information, allowing them to compare prices and reviews in a trustworthy environment. This improved transparency facilitates more informed purchasing decisions [66]. Moreover, blockchain enables cryptocurrency and token-based payments, further eliminating financial intermediaries and enhancing the efficiency of digital commerce.

This section primarily focuses on the application of blockchain in the fast fashion industry, which is characterized by short product life cycles, rapid production turnover, and a wide variety of products. However, while some challenges, such as counterfeiting and supply chain transparency, are common across both fast fashion and luxury fashion sectors, their approaches to blockchain adoption differ. Luxury fashion brands prioritize authenticity verification and sustainability, while fast fashion brands focus on supply chain efficiency and cost reduction [67]. In this research, we primarily analyze blockchain's impact on fast fashion, but relevant examples from luxury brands are included where applicable to highlight shared challenges and solutions. Blockchain provides tailored solutions for both sectors, but its application varies based on industry needs [68].

VeChain by BitSE platform is utilized by brands such as Baby Ghost, H&M, LVMH, Walmart China, etc. VeChain is used to combat counterfeiting, allowing brands to provide proof of product authenticity and build trust among consumers [69]. This technology enables customers to track the origin and journey of products. TextileGenesis is a blockchain-based platform used in the fashion and textile industry to enhance traceability and transparency throughout the supply chain [70]. Loomia integrates advanced technology into fabrics through partnerships with companies like Festo and Alessandro Gherardi, embedding IoT sensors, heating elements, and lighting components to enable functionalities such as temperature regulation, data collection, and personalization, and uses blockchain technology to ensure secure data integrity, enhance traceability, and verify the authenticity of the information collected [3]. In the realm of lifecycle tracking, Everledger collaborates with brands such as Alexander McQueen and Brilliant Earth. Everledger is the technology collaborator for the new brand [71]. It ensures that a secure and permanent digital record of each item is entered on the blockchain, enabling collectors to see the lifecycle of each item, charting its origins to the first purchase, and even resale. Lastly, SourceMap supports companies like BeautyCounter and Timberland with their suite of supply chain tools. SourceMap technology encompasses the full suite of supply chain due diligence requirements, including supplier discovery, supply chain mapping, supplier risk assessment, transaction traceability, resilience planning, real-time visualization, and consumer-facing transparency [72].

3. Model for Fashion Product Traceability and Authenticity Based on Blockchain

Supply chain models in the fashion industry are faced with challenges such as lack of transparency, counterfeiting, and data fragmentation. Having these challenges and issues in mind, this paper presents a model for fashion product traceability and authenticity based on blockchain (Figure 1) which aims to facilitate connections between the various stakeholders in the fashion supply chain while ensuring a secure and transparent platform for transactions and data storage. The integration of blockchain into the e-commerce ecosystem creates benefits for all stakeholders by enhancing transparency, security, and efficiency [73]. Manufacturers, suppliers, and retailers benefit from real-time information sharing and automated processes, reducing operational delays and errors. Consumers gain access to trustworthy product information and secure payment methods, enhancing their shopping experience and trust in the system. Financial institutions and logistics providers benefit from transparent and secure transactions, reducing the risk of fraud and improving service delivery. Government and regulatory bodies can monitor compliance more effectively, ensuring that industry standards are met.

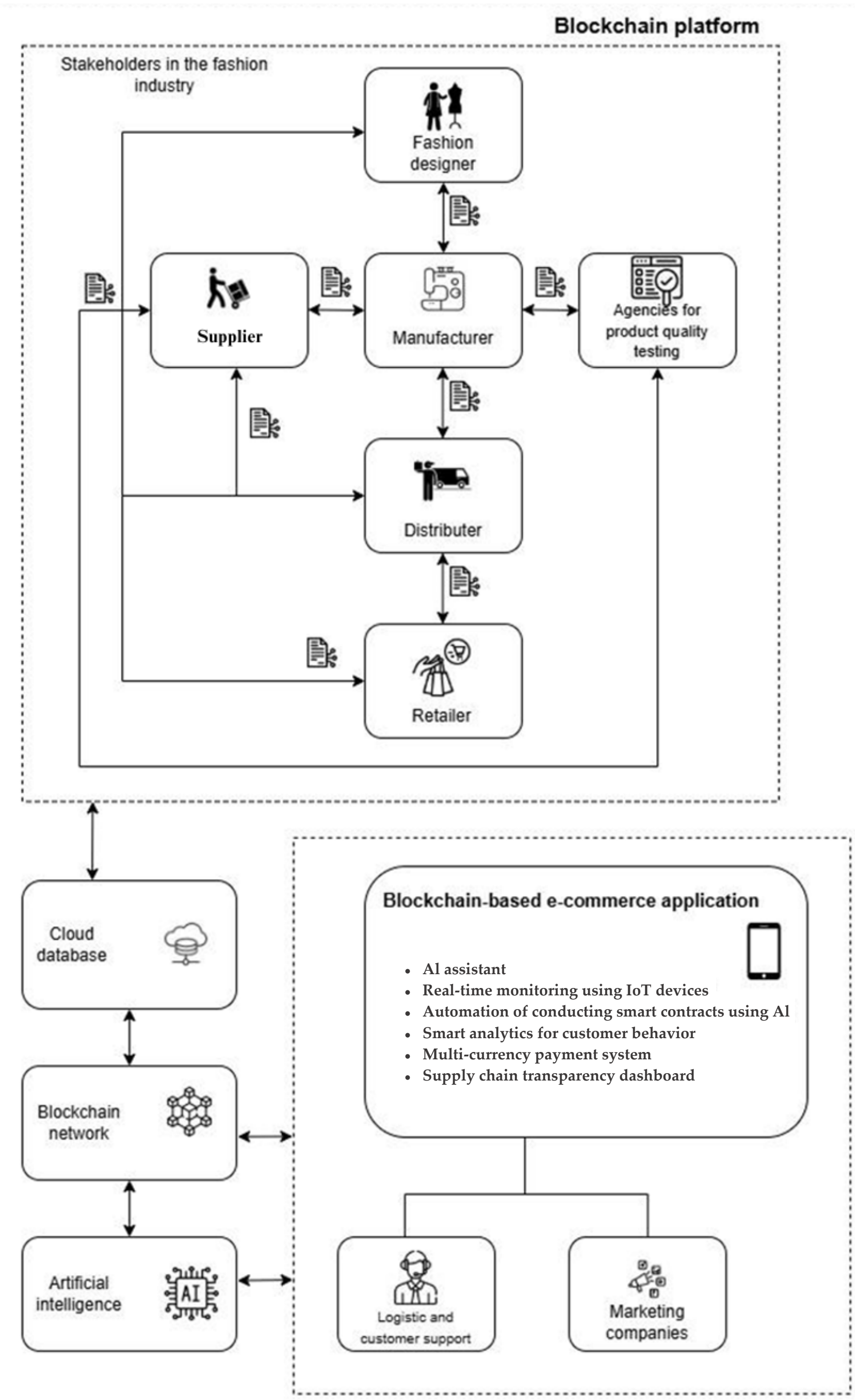

Figure 1. Model for fashion product traceability and authenticity based on blockchain.

It is crucial for each participant in the supply chain to receive all the necessary information from their counterparts while maintaining insight into all processes within the supply chain. The implementation of smart contracts between participants allows each party to articulate its requirements and conditions. This ensures trust and eliminates opportunities for fraud and abuse among participants. Financial transactions within the blockchain system are executed using smart contracts, digital wallets, and e-banking services. The blockchain ledger, embedded within the chosen blockchain platform, securely stores all transaction data. This includes a comprehensive set of information within the cloud database: stakeholders' data, supply chain data, smart contracts between stakeholders, transaction data, product data, and customer data.

Integration of IoT, AI, and big data with blockchain further enhances the transparency, efficiency, and sustainability of the fashion supply chain. Tracking raw materials, monitoring shipments, and providing proper storage conditions are all catered for through IoT devices such as RFID tags and smart sensors; real-time data are recorded on the blockchain [74]. AI algorithms further analyze this data to optimize inventory, predict demand, and identify inefficiencies in order to reduce waste and cut down on costs [75]. Meanwhile, big data analytics sweeps through large volumes of information stored on blockchains to offer valuable insights into the performance of consumers, suppliers, and ethical sourcing trends. This smart integration supports automated decision-making, builds trust within the supply chain, and drives business practices that are more sustainable and consumer-driven [16].

Table 1 provides an overview of each stakeholder, outlining their roles in the ecosystem, the processes they participate in, the documents they exchange, and the value they contribute.

In the proposed blockchain system for the fashion industry, the fashion designer records information about suppliers, raw materials, construction, and modeling instructions for the manufacturing process. These details are contained in the design documents, material specifications, and modeling instructions. Transactions between the designer and manufacturer are facilitated through smart contracts, which outline specific requirements for materials and construction methods, ensuring the clothes are produced according to precise designs and standards. This approach maintains the integrity of the designer's vision throughout the production process.

Suppliers record data related to raw and packaging materials and cooperate with quality testing agencies to ensure these materials meet the necessary standards. They provide raw material specifications and quality certificates to manufacturers, ensuring that only verified and quality-controlled materials are used in production. The supplier's interactions are regulated through smart contracts, which establish clear standards for product quality.

Manufacturers, in turn, collect required information from fashion designers, including design documents, material specifications, and modeling instructions. They procure raw materials from suppliers, adhering to the standards set in smart contracts. During the production process, manufacturers record manufacturing reports and quality test results, ensuring the final products meet the required standards. They also handle logistics by recording warehouse data, transport logs, and monitoring temperature levels, ensuring proper storage and timely delivery of products.

In this integrated blockchain system, each stakeholder—fashion designer, supplier, manufacturer, quality testing agency, distributor, retailer, and customer—fulfills their part of the supply chain, adding value at each stage. The blockchain allows transparent and secure interactions through smart contracts, ensuring that each actor adheres to predefined standards and protocols. Fashion designers benefit from the integrity of their designs being maintained, while suppliers ensure the quality of raw materials through verified certifications. Manufacturers streamline production and logistics. Quality-testing agencies provide quality assurance data, bolstering product reliability. Distributors manage efficient and safe delivery, while retailers ensure product presentation and inventory management.

Table 1. Participants in the supply chain and their activities.

Stakeholder	Role	Activities/ Processes	Documents Exchanged	Value to the Model
Fashion Designer/ Company	Creator of designs	Recording supplier info Defining raw materials Specifying construction and modeling instructions	Design documents Material specifications and construction Modeling instructions	Ensure design integrity and quality consistency
Supplier	Provider of raw materials and packaging	Recording raw material data Engaging with quality testing agencies Selling materials to manufacturers	Raw material specifications Quality certificates	Supply of verified and quality-controlled materials and packaging
Manufacturer	Producer of clothing	Collecting design and material info Procuring raw materials Recording manufacturing and quality data	Manufacturing reports Quality test results Quantities, delivery timelines, and other logistics details	Ensure proper production adhering to design and quality
Quality Testing Agencies	Quality assurance	Testing product and raw material quality Reporting results	Quality test reports Conditions of the testing process Testing methodologies	Maintain product and material quality standards
Distributor	Manager of distribution process	Recording warehouse data Monitoring product storage and transport	Warehouse records Transport logs Temperature levels	Ensure timely and safe delivery of products
Retailer	Manager of product sale	Recording new arrivals Maintaining stock status Managing product presentation	Inventory records Procurement orders Terms and conditions of the transactions	Provide access to end consumers and manage inventory
Customer	End consumer	Engaging via e-commerce Tracking orders Communicating with supply chain stakeholders Making transactions using debit cards or digital wallets	Purchase orders Payment receipts Feedback	Drives demand and provides feedback for continuous improvement

The culmination of this collaboration is a consumer experience focused on tracking, trust, and sustainability. Customers can access comprehensive information about their purchases, starting with the product's origin. This includes details about the source and manufacturing location, allowing consumers to make informed decisions based on the product's provenance. This level of transparency fosters trust between consumers and brands, ensuring that buyers can confidently support companies that align with their personal values.

Customers also gain insights into the fabrics used in the product, including their composition and sourcing, as well as the production process, which details the construction methods and modeling instructions employed. This information not only adds to the product's story but also provides assurance regarding its quality and craftsmanship. The availability of the production date further contributes to transparency, informing consumers about the product's freshness and relevance. Additionally, detailed quality-testing information assures customers that the product adheres to stringent standards.

The blockchain system strengthens consumer trust and brand loyalty by ensuring accurate and reliable product information. To achieve this, every step in the supply chain must be recorded without gaps, as any missing data could raise concerns about product authenticity or quality. A flawlessly functioning system gives consumers confidence in their purchases, ultimately enhancing brand reputation and long-term market sustainability.

Validation Gap

The introduction of new advanced technologies in the fashion industry also contributes to the increasing complexity and diversity of global supply chains, making the validation of a blockchain model applied to the fashion industry not only challenging but also logistically and technically demanding, especially in conducting effective testing in collaboration with manufacturers, suppliers, distributors, and retail chains.

Although simulations can provide valuable insights, they cannot fully replicate the unpredictability of real-world operations, such as delivery delays, fluctuations in demand, or data manipulation by different participants. Another limitation is the technical adaptation of blockchain systems, as different fashion brands use diverse digital infrastructures that are not easily integrated. Additionally, the model's feasibility should not be evaluated solely from the consumer perspective, but also from the standpoint of fashion brands, technology providers, and logistics operators, who are critical in determining its practical implementation. Fashion brands often use ERP systems such as SAP or Oracle, along with RFID and IoT solutions, as well as cloud databases for inventory tracking [76]. Our blockchain platform can integrate with these systems via standard RESTful APIs or similar protocols, enabling automatic and secure data updates within existing supply chain management and e-commerce environments [77].

To address these challenges, the validation of the proposed model could be approached conceptually by involving key stakeholders in the evaluation process. Stakeholder engagement methods, such as focus groups, expert interviews, and feasibility assessments, could provide insights into the model's adaptability even before real-world deployment. Additionally, industry-driven simulations using real supply chain data could help test transparency, security, and efficiency, involving multiple actors rather than focusing exclusively on consumer behavior.

A broader validation approach incorporating perspectives from fashion brands, suppliers, technology providers, and consumers would ensure that blockchain is a sustainable technology for the fashion industry, addressing technical, logistical, and economic feasibility beyond its potential benefits for end consumers.

4. Examining Customers' Readiness to Buy Fashion Products Authenticated with Blockchain

To ensure the success and viability of this blockchain system, it is necessary to understand how consumers will interact with and accept these new functionalities. For this reason, conducting acceptance studies is crucial. These studies help identify the factors that influence consumer adoption and use of technology, providing valuable information into consumer behavior and preferences. By understanding what drives consumers to embrace a blockchain system, the industry can tailor the blockchain features to better meet user needs and expectations. This is particularly important for ensuring the financial viability of the system, as widespread acceptance and usage are necessary for it to be sustainable.

4.1. Methodology and Research Hypotheses

For the purposes of this study, the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) was used to evaluate the factors that impact users' intention to adopt blockchain technology in the fashion industry. The UTAUT2 adds hedonic motivation, price value, and habit to the original UTAUT model constructs of performance expectancy, effort expectancy, social influence, and facilitating conditions [78]. This model assists in understanding and predicting technology acceptance through an examination of the differential influences of factor constructs such as age, gender, and experience on technology adoption behavior. It is also based on the technology acceptance model (TAM) [79]. The selection of these latent variables is grounded in established technology adoption theories. The technology acceptance model [7] identifies perceived usefulness and ease of use as critical determinants of technology acceptance. In addition to the original TAM formulation, several studies have extended and adapted the model to better capture consumer behavior in digital environments. For example, the authors of [8] proposed an extended TAM for electronic transaction systems, incorporating variables such as trust and compatibility, while [9] applied a TAM in combination with flow theory to explain online consumer behavior, highlighting the importance of intrinsic motivation and user engagement. UTAUT2 expands on the TAM by incorporating additional constructs relevant to consumer decision-making, such as hedonic motivation and price value [78]. However, given the nature of blockchain technology in the fashion industry, variables like perceived risk [14] and trust [13] play a crucial role, as consumers must be assured of data security and transaction reliability. Additionally, social influence and facilitating conditions remain essential factors in the adoption of decentralized technologies [80]. These theoretical foundations justify the inclusion of the selected variables in this study. Expected effort refers to the ease with which users can adopt new technology [7]. Social influence assesses how much users feel that important people around them believe they should use the new technology [81]. Facilitating conditions describe the extent to which users believe that organizational and technical support facilitates the adoption of new technology. Hedonic motivation defines the pleasure or enjoyment derived from using technology, significantly affecting user acceptance by enhancing satisfaction during use. Price value assesses the economic feasibility of the technology, influencing user decisions by considering whether financial benefits outweigh the costs, encompassing all associated expenses related to the use of the technology. Habit describes how habitual use of technology influences user behavior [82].

Based on the UTAUT2 framework, this study examines key factors influencing the adoption of blockchain technology in the fashion industry. The analyzed variables include effort expectancy, perceived risk, social influence, perceived efficiency, price value, facilitating conditions, consumer habits, and trust. These factors have been widely studied in technology adoption research and are adapted to the specific context of blockchain-based supply chain applications [83]. Understanding how these constructs influence consumer readiness to adopt blockchain provides a structured approach to analyzing adoption barriers and enablers.

Based on the modified UTAUT2 model applied in this research, the following hypotheses can be derived:

H1. *Expected effort influences consumers' readiness to use blockchain technology implemented within the fashion industry.*

H2. *Perceived risk of consumers influences their readiness to use blockchain technology implemented within the fashion industry.*

H3. *Social influence affects consumers' readiness to use blockchain technology implemented within the fashion industry.*

H4. *Perceived efficiency influences consumers' readiness to use blockchain technology implemented within the fashion industry.*

H5. *Price value perceived by consumers affects their readiness to use blockchain technology implemented within the fashion industry.*

H6. *Facilitating conditions perceived by consumers affect their readiness to use blockchain technology implemented within the fashion industry.*

H7. *The habits of consumers significantly affect their willingness to adopt blockchain technology in the fashion industry.*

H8. *Trust gained by consumers influences their readiness to use blockchain technology implemented within the fashion industry.*

Figure 2 shows the UTAUT2 model tailored to our research on blockchain technology's application in the fashion industry. To adapt the UTAUT2 model for assessing blockchain acceptance in the fashion industry—specifically for tracking the origin of fashion items—the original UTAUT2 variables were modified to align with the specific requirements of this context. These modifications allow for a more precise analysis of the factors influencing user acceptance and engagement. Blockchain systems are particularly influenced by perceived risk and trust, as these factors are crucial for understanding consumer concerns regarding the security and reliability of blockchain technology. Additionally, some of the original UTAUT2 variables, such as hedonic motivation, were omitted as they were deemed less relevant for evaluating the acceptance of a blockchain-based system for tracking the origin of fashion items. In this modified model, we set individual differences such as age, gender, education, and role/status to influence the dependent variable, i.e., expected behavior.

In the context of blockchain adoption in the fashion industry for product provenance tracking, some of the constructs within UTAUT2, like hedonic motivation, turn out not to be fundamentally relevant for explaining the factors that could influence the adoption of this technology [80]. Hedonic motivation is the fun and pleasure that the users experience from using a technology, which traditionally is essential in digital platforms designed for entertainment, such as video games or social media. However, within the context of blockchain solutions for traceability in fashion products, the core added value of such technology lies not in giving joy to its users but rather in providing the ability to guarantee data security, transparency, and dependability of supply chain data [84].

The need for blockchain solutions in fashion to track the number of items connected with sustainable consumerism and production has grown considerably over recent times No one in this system—neither consumers nor brands—uses it for pleasure, but rather for its potential to provide verified information about a product's origin and authenticity. A lot more emphasis is placed on data transparency and security than this vague idea of pleasure in interaction with technology. Previous research has indicated that, in fields where practical and safety needs dominate, such as the area of digital banking and data management systems, hedonic motivation plays a marginal role in the choice of technology adoption [85].

The slightly modified UTAUT2, as adopted for this study, presents a framework within which to examine the main factors that determine consumers' readiness to adopt blockchain technology in the fashion industry, especially for tracking product provenance.

Effort Expectancy. When consumers find the use of blockchain technology to be effortless and intuitive, then they adopt it easily. Tracking of the product's provenance through blockchain should be made accessible with an interactive interface. This predictor supports H1 which investigates the influence of effort expectancy on consumers' readiness to use blockchain in the fashion industry.

Social Influence. Consumers will be more likely to adopt blockchain technology if they perceive it as widely accepted in the industry or if they know others who use it. This predictor supports H3, which examines the influence of social influence on consumers' readiness to use blockchain in the fashion industry.

Price Value. Consumers will only adopt blockchain if they feel the benefits from using blockchain in terms of heightening security and data reliability are more than the costs or complications involved. This predictor supports H5, which evaluates the influence of price value on consumers' intention to use blockchain in the fashion industry.

Facilitating Conditions. The adoption is more likely if the consumers have easy access to data and enough support while using the technology. This predictor supports H6, which examines the impact of these conditions on consumer preparedness to use blockchain technology.

Habits. Consumers who are already accustomed to checking the provenance of products through digital means, such as online reviews and certifications, would find it much easier to accept blockchain as a new way to access information. This predictor supports H7, which examines the role of consumer habits in the adoption of blockchain technology within the fashion industry.

Building further on this premise in order to provide a theoretical background for the current research, an extension of UTAUT2 is made in the form of three important factors playing a central role in the adoption of blockchain technology by industry participants for fashion product provenance tracking. In so doing, these predictors serve to better perceive consumer decision-making and their attitude toward new technologies in the supply chain.

The ***perception of risk*** is an important factor in understanding consumer uncertainty in the adoption of blockchain technology and supports Hypothesis H2 in examining its impact on consumers' readiness to adopt blockchain in the fashion industry. Consumers may feel afraid of technical malfunction, lack familiarity with the technology, or even the reliability of data recorded in the system [14].

Consumers' ***perceived efficiency*** is a significant factor in their intention to adopt blockchain technology because they will be more inclined to adopt it if they perceive that the technology will increase the transparency and security of product origin information. This predictor supports H4, which explores the influence of perceived efficiency on consumer adoption.

Another core role that would also be played in the adoption of blockchain in the fashion industry is that of ***trust,*** since consumers need to be able to assure themselves that the information included in the supply chain is accurate, the records are secure, and the system is reliable. This perception by consumers that the system is trustworthy, and capable of ensuring the authenticity of a product will enhance its adoption. This supports H8, analyzing the influence of trust on consumer readiness to use blockchain in the fashion industry [14].

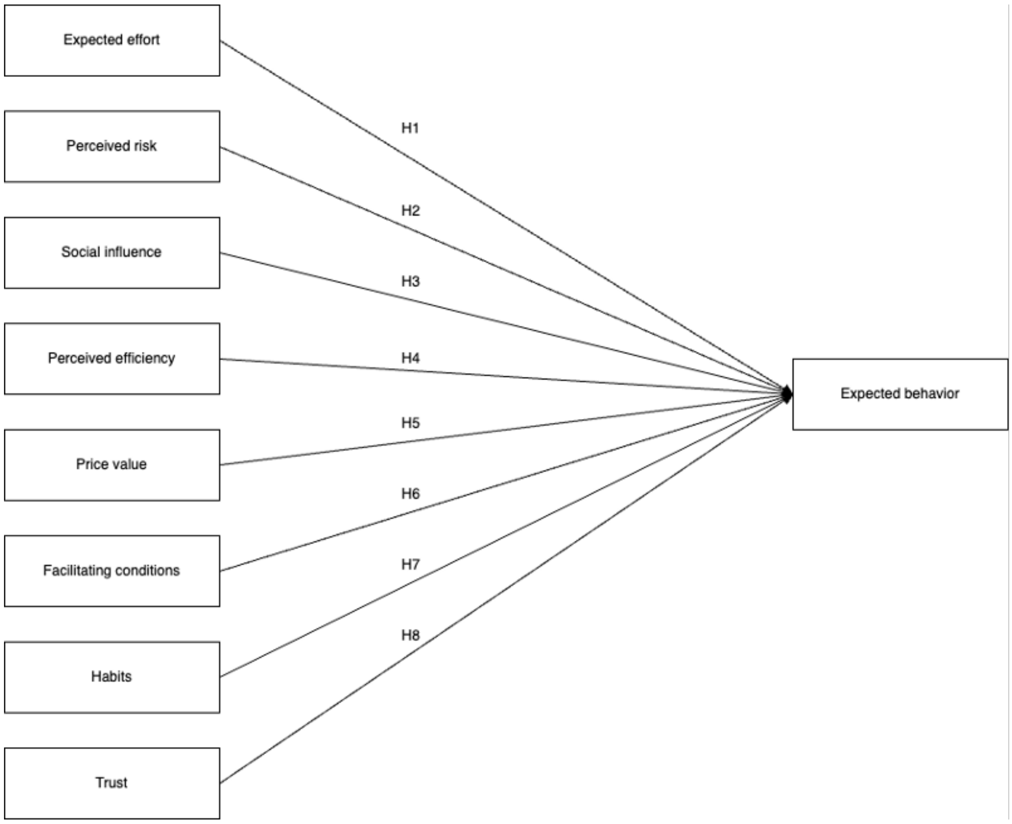

Figure 2. Modified UTAUT2 model [86].

4.2. Research Study

The following subsection presents an overview of the analysis results concerning consumers' readiness to adopt blockchain technology in the fashion industry. The analysis was conducted to determine the extent and nature of the interdependence between the constructs used in the study and consumers' expected behavior. The SmartPLS 4.0.8.2 software tool was employed for the analysis to investigate the relationships between the variables used and consumers' expected behavior.

Regarding the target group for this research, the data collection was conducted through a survey involving a structured questionnaire. The majority of respondents were young individuals familiar with online shopping and interested in fashion trends. While this group represents ideal consumers for assessing the readiness to introduce blockchain technology in the fashion industry, it is important to note that a more diverse population sample would provide a better representation of the general population. This is one of the current limitations of the study, as acceptance studies aim to encompass a wider audience, not just the current target group. In the future, a broader group of respondents will be considered, but this population represents the best starting point for such a study.

A total of 241 respondents participated in our survey, and each of them initially had to answer some basic demographic questions, allowing us to draw preliminary conclusions about this target group. Subsequently, we analyzed these basic demographic questions and identified similarities and differences among the respondents.

The survey began with a question about the respondents' age. The data reveal that the largest group of respondents (55.6%) were between 20 and 25 years old, which aligns with Generation Z, defined here as individuals born between 1995 and 2012. The second largest group (23.2%) included respondents over the age of 35, likely representing a mix of late Millennials (born between 1981 and 1996) and Generation X (born between 1965 and 1979).

Respondents aged 25 to 35 (14.9%) also span these two cohorts: the younger segment of this group may still fall into Generation Z (born 1995–1997), while the older segment is clearly within the Millennial range. The smallest group, comprising 6.2% of the sample, consists of respondents under the age of 20, also part of Generation Z. This distribution indicates that the research predominantly reached younger generational cohorts—Generation Z and Millennials—who are generally more digitally literate and more inclined to adopt emerging technologies. Nevertheless, the presence of older respondents provides valuable insights into the perspectives of more experienced consumers, particularly those from Generation X, regarding blockchain adoption in the fashion industry.

Next, the survey addressed the gender of the respondents. It was found that females made up a significantly higher proportion of the sample at 63.1%, compared to 36.9% who were male.

Regarding the current status of the respondents, a majority were still students, comprising 56% of the sample. Employed individuals made up 37.8%. The remaining respondents included unemployed individuals, retirees, and pupils, though these groups were much smaller in percentage.

When it came to educational levels, over 40% of the respondents had higher education, with 48.1% holding college or university degrees. High school graduates accounted for 34.4%, while those with postgraduate studies made up 17.4%. Notably, none of the respondents possessed only elementary education. This indicates that a large portion of the respondents had either higher or high school education, making the distribution compatible with the research objectives.

The demographic characteristics of the survey participants are also displayed in Table 2.

Table 2. Demographic characteristics of respondents.

	Variable	Value	Frequency	Percentage (%)
Demographic Characteristics	Age	Gen Z (under 20)	15	6.2%
		Gen Z (from 20 to 25)	134	55.6%
		Millennials (from 25 to 35)	36	14.9%
		Gen X (over 35)	56	23.2%
	Gender	Male	89	36.9%
		Female	152	63.1%
	Status	Student (High School)	3	1.2%
		Student (University)	135	56%
		Employed	91	37.8%
		Unemployed	7	2.9%
		Retired	5	2.1%
	Education	Primary Education	0	0%
		High School Education	83	34.4%
		College/University	116	48.1%
		Postgraduate Studies	42	17.4%

The classification of respondents by generation enables a more nuanced understanding of potential adoption trends. Generation Z (born between 1995 and 2012), which includes the majority of respondents aged under 26, represents digital natives who have grown up in an internet-centric world, making them especially open to adopting blockchain technology for enhancing transparency in the fashion supply chain. Millennials (born between 1981 and 1996), primarily represented among respondents aged 28–35, possess considerable experience with e-commerce, digital payments, and online platforms, which contributes to their receptiveness toward the benefits of blockchain. Meanwhile, respondents over the age of 35 may include both late Millennials and members of Generation X (born between 1965 and 1979), who tend to be more cautious about adopting emerging technologies and may require additional information, trust-building, and incentives [87,88]. These generational distinctions offer valuable insights into different market segments and their readiness for blockchain adoption in the fashion industry.

The last in the series of demographic questions related to how familiar respondents were with blockchain technology, and whether they knew anything about this modern technology at all. Based on their responses, we noted that the majority, 72.6%, had heard of blockchain technology, while 27.4% had not heard anything about it. This suggests that although many respondents were aware of blockchain technology, a substantial group remains unfamiliar with it. We did not exclude 27.4% of respondents who had not heard of blockchain, because their answers reflect the actual level of consumer awareness and help us understand how lack of familiarity affects attitudes and intentions. We treated the "never heard of blockchain" group as a valid baseline to quantify how unfamiliarity reduces willingness to engage, rather than discarding their responses. For questions that required basic knowledge of blockchain, their responses did not influence the results for those items, but all other data from these respondents were retained in the analysis. In this way, we obtain a more complete and less biased picture of the population.

5. Analysis of Results

For a more in-depth analysis of the interdependence of constructs and consumer behavioral expectations, the PLS-SEM method was employed. A model was constructed to examine the relationships between the utilized constructs and the dependent variables representing expected behavior. The survey data did not exhibit any suspicious response patterns or inconsistent answers.

The constructs are latent variables, each represented by survey questions. From the diagram, it is observed that there are eight latent variables: expected effort (EE), perceived risk (PR), social influence (SI), perceived efficiency (PE), price value (PV), facilitating conditions (FC), habits (HT), and trust (TR). These latent variables can influence consumers' readiness to adopt blockchain technology in the fashion industry. The dependent variable is expected behavior.

In the SmartPLS software tool, the model underwent two algorithms: the PLS algorithm and bootstrapping. After applying the PLS algorithm to the model, the final results were interpreted. By examining the table with outer loadings, it was identified that certain questions did not fit well with their respective constructs, indicating that they did not provide sufficiently reliable results for the assigned constructs.

Survey questions that did not yield satisfactory results for their assigned constructs include: FC4, HT1, HT2, PR1, PR4, PR5, PV2, PV3, SI1, TR1, TR2, and EE1. Since these questions were inappropriate, they were excluded from the final analysis. The PLS algorithm was then run again on a new model excluding these questions. All these questions can be found at the end of the paper in Appendix A.

The new model, without the previously mentioned questions, is shown in Figure 3. The figure shows the new model on which the PLS algorithm was executed, containing only questions that are appropriate and reliable for the assigned constructs. R-squared values determine the proportion of variance in the dependent variable that can be explained by the independent variable. The higher the R-squared value, the better the model. In our case, this component's value is 0.729, meaning that the model accounts for 72.9% of the variability in the dependent variable. Consequently, we can conclude that our model has sufficient predictive capabilities.

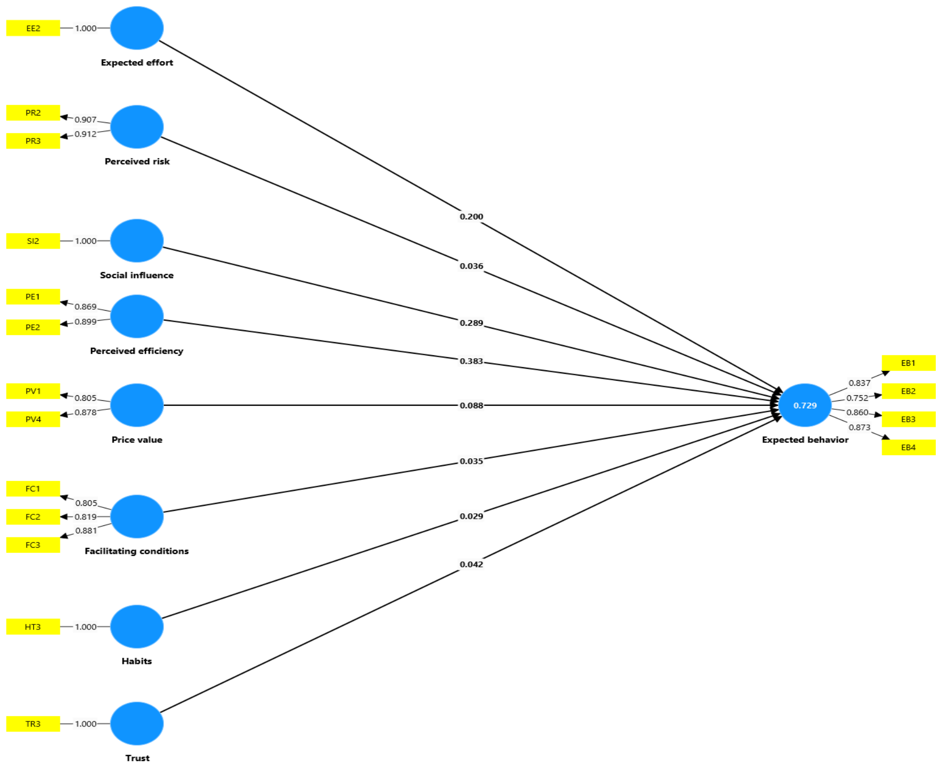

Figure 3. The result of PLS-SEM algorithms performed on the new model.

The model was validated through two phases: the latent variable measurement model was assessed in the first phase, and the structural model was evaluated in the second phase. The results are available in relation to the application of the PLS-SEM method and the PLS algorithm.

Cronbach's alpha is a measure of internal consistency. It indicates how consistent a set of items are when considered as a group. It is used to determine the reliability of Likert scale-based surveys with multiple questions. Values range between 0 and 1, with values above 0.7 considered good. From Table 3, we can see that all our question groups for specific variables are acceptable, except for the group related to price value. Only this question group has Cronbach's alpha values below 0.7, indicating inconsistency in measuring the assigned variables. Average variance extracted (AVE) is a parameter indicating the positive correlation between indicators describing a single variable. Based on the final results, all our indicators show a sufficient level of positive correlation, higher than the recommended 0.5.

Composite reliability represents the perimeter of composite reliability and, like Cronbach's alpha, is used to measure internal consistency. Values between 0.6 and 0.7 are acceptable, while values above 0.9 are not desirable. The optimal range is between 0.7 and 0.9, with values above 0.95 being the least favorable. According to our final results, all values are between 0.8 and 0.9, except for the values for price value, which is entirely satisfactory. The use of cross-loadings determines the extent to which variables in the model differ from one another. In our research, as we can see in Table 4, the indicator values for each variable are greater than the values associated with other variables. Specifically, each indicator has the highest cross-loading value with the variable it is assigned to.

Table 3. Evaluation of the validity of the latent variable measurement model.

	Indicators	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
Expected behavior	EB1, EB2, EB3, EB4	0.850	0.857	0.899	0.692
Facilitating conditions	FC1, FC2, FC3	0.791	0.849	0.874	0.698
Perceived efficiency	PE1, PE2	0.722	0.729	0.878	0.782
Perceived risk	PR2, PR3	0.792	0.792	0.906	0.828
Price value	PV1, PV4	0.594	0.612	0.830	0.709

Table 4. Measured cross-loading values.

	Expected Behavior	Expected Effort	Facilitating Conditions	Habits	Perceived Efficiency	Perceived Risk	Price Value	Social Influence	Trust
EB1	0.837	0.588	0.266	0.235	0.699	0.224	0.457	0.618	0.347
EB2	0.752	0.526	0.191	0.115	0.605	0.180	0.346	0.452	0.179
EB3	0.860	0.445	0.412	0.221	0.653	0.282	0.488	0.701	0.216
EB4	0.873	0.515	0.410	0.226	0.635	0.304	0.432	0.686	0.279
EE2	0.622	1.000	0.357	0.240	0.534	0.315	0.445	0.474	0.237
FC1	0.274	0.288	0.805	0.311	0.211	0.248	0.291	0.216	0.263
FC2	0.253	0.243	0.819	0.333	0.147	0.285	0.342	0.224	0.206
FC3	0.411	0.345	0.881	0.403	0.315	0.296	0.474	0.363	0.299
HT3	0.244	0.240	0.424	1.000	0.128	0.187	0.341	0.201	0.206
PE1	0.646	0.458	0.193	0.149	0.869	0.246	0.391	0.593	0.193
PE2	0.729	0.486	0.303	0.081	0.899	0.152	0.433	0.727	0.220
PR2	0.270	0.307	0.303	0.173	0.205	0.907	0.352	0.179	0.132
PR3	0.276	0.266	0.300	0.168	0.198	0.912	0.298	0.206	0.158
PV1	0.390	0.413	0.456	0.340	0.285	0.286	0.805	0.321	0.299
PV4	0.482	0.347	0.330	0.247	0.483	0.314	0.878	0.351	0.154
SI2	0.745	0.474	0.336	0.201	0.750	0.212	0.399	1.000	0.300
TR3	0.311	0.237	0.313	0.206	0.234	0.160	0.259	0.300	1.000

On further examination of the final results, we observed the Fornell–Larcker criterion for validity, which helps us assess the comparison between variable correlations and the AVE values shown in Table 3. Based on the correlation matrix displayed in Table 5, we can see that validity is achieved for all variables.

VIF (Variance inflation factor) values can be used for the evaluation of collinearity. From Table 6, we can see that none of the VIF values exceeds five. Hence, we can conclude that there is no collinearity among the variables.

Table 5. Fornell–Larcker criterion.

	Expected Behavior	Expected Effort	Facilitating Conditions	Habits	Perceived Efficiency	Perceived Risk	Price Value	Social Influence	Trust
Expected behavior	0.832								
Expected effort	0.622	1.000							
Facilitating conditions	0.390	0.357	0.836						
Habits	0.244	0.240	0.424	1.000					
Perceived efficiency	0.780	0.534	0.284	0.128	0.884				
Perceived risk	0.300	0.315	0.331	0.187	0.222	0.910			
Price value	0.521	0.445	0.457	0.341	0.467	0.357	0.842		
Social influence	0.745	0.474	0.336	0.201	0.750	0.212	0.399	1.000	
Trust	0.311	0.237	0.313	0.206	0.234	0.160	0.259	0.300	1.000

Table 6. Measured VIF values.

	VIF
Expected effort	1.604
Facilitating conditions	1.554
Habits	1.290
Perceived efficiency	2.700
Perceived risk	1.224
Price value	1.661
Social influence	2.461
Trust	1.178

After applying the bootstrapping method, our modified model is shown in Figure 4.

The bootstrapping method was conducted using 5000 samples and a significance level of 5% to further analyze our research. We focused on the relationships between variables analyzed using the path coefficient values from the structural model. A strong positive relationship for a particular link is indicated if the value is close to +1, indicating statistically significant relationships. Conversely, if the value is close to −1, it signifies strong negative relationships. An influence is considered nonexistent if the value is equal to 0. It is important to note that all path coefficient values in the model are shown as zeros. This result clearly indicates that there are no statistically significant impacts between the examined constructs and expected behavior, which may point to deeper methodological challenges within the research.

By testing the hypotheses, it can be determined which variables have the most influence on the adoption of blockchain technology in the fashion industry and which of the offered variables were significant for the research and which had the least impact. The results of hypothesis testing are presented in Table 7.

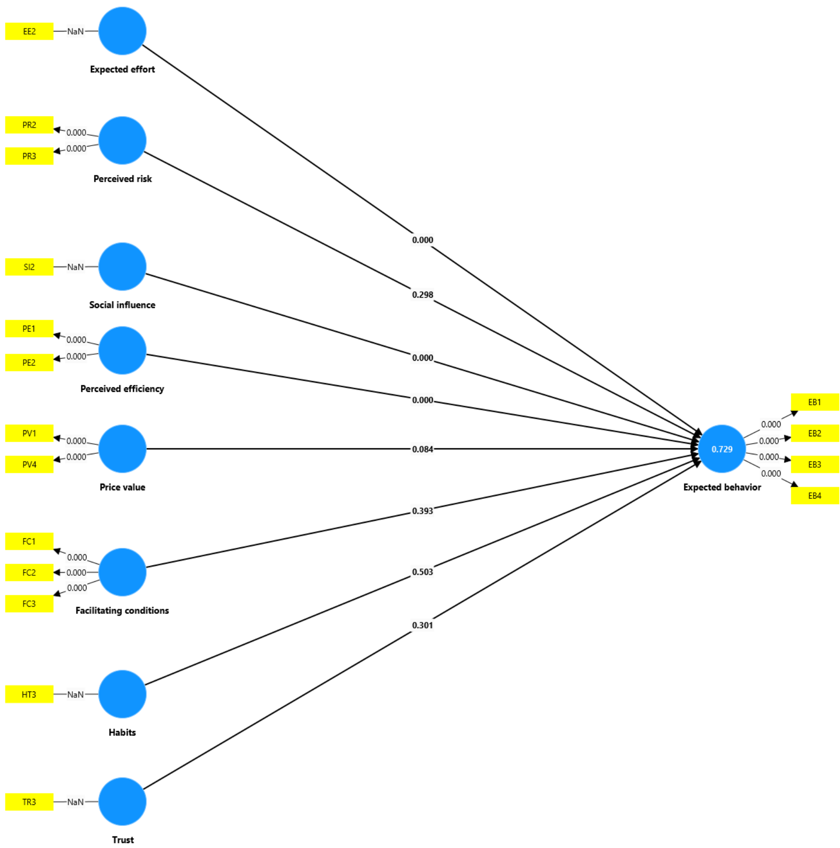

Figure 4. Application results of the bootstrapping method.

Table 7. Hypothesis testing.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p* Values
Expected effort → Expected behavior	0.200	0.199	0.047	4.239	0.000
Facilitating conditions → Expected behavior	0.035	0.037	0.040	0.855	0.393
Habits → Expected behavior	0.029	0.027	0.043	0.670	0.503
Perceived efficiency → Expected behavior	0.383	0.379	0.074	5.195	0.000
Perceived risk → Expected behavior	0.036	0.037	0.035	1.041	0.298
Price value → Expected behavior	0.088	0.091	0.051	1.729	0.084
Social influence → Expected behavior	0.289	0.292	0.062	4.649	0.000
Trust → Expected behavior	0.042	0.043	0.040	1.035	0.301

Based on the obtained data, it can be concluded that some indicators are statistically significant while others are not. The indicators identified as having the greatest importance and the most significant impact on expected behavior are expected effort, perceived efficiency, and social influence. Therefore, we conclude that hypotheses H1, H3, and H4 are confirmed.

Future research should focus more on the indicators that did not show a significant impact on consumers' expected behavior in this study. Insights into why facilitating conditions, habits, perceived risk, price value, and trust do not significantly influence the adoption of blockchain technology by consumers could provide a deeper understanding and assist in developing more effective strategies.

All results of hypothesis testing indicate that attention must be given to all significant indicators that have the most substantial influence on consumers' expected behavior. To foster a positive attitude towards adopting blockchain technology in the fashion industry, a clear understanding of what blockchain can offer, how social influences may affect consumers, and what effort is expected from them is necessary.

By addressing these key factors, the promotion of blockchain technology adoption and leveraging its potential benefits in the fashion industry can be improved.

6. Conclusions and Discussion

This paper proposes a supply chain management approach for the fashion industry, based on the use of blockchain technology. The platform integrates blockchain with artificial intelligence, IoT devices, and cloud databases to enable the drafting of smart contracts, real-time tracking of products, and analysis of consumer behavior. All the actors in the fashion supply chain and their willingness to embrace blockchain-enabled innovative solutions depending on their various needs and positions were targeted in the study.

Tracking the origin of products in the fashion industry is essential for ensuring quality and adherence to ethical standards in production [12]. Traditional systems for tracking origins often suffer from a lack of transparency, the possibility of data falsification, and the complexity in verifying each step in the supply chain [89]. Blockchain technology can address these issues through its decentralized and immutable nature, where every entry in the supply chain can be permanently recorded and verified by all participants [90].

Existing models for tracking product origin in the fashion industry often address specific issues but fail to offer a comprehensive supply chain solution [91]. Models that do not encompass the entire supply chain often have information gaps, limiting traceability and data reliability [92]. This paper proposes a blockchain model that integrates all supply chain phases, ensuring complete verification and enhanced data security [93].

6.1. Theoretical and Managerial Contributions of the Proposed Model

The contribution of this research lies in the model developed for fashion product traceability and authenticity based on blockchain and the conducted acceptance study. The findings of this study contribute both theoretically and practically to the growing body of research on blockchain adoption in the fashion industry. While previous models have largely focused on technical traceability solutions or supply chain efficiency [11], this study extends the discussion by integrating consumer adoption behavior into blockchain frameworks. The proposed model offers a comprehensive approach by incorporating smart contract automation, decentralized authentication, and consumer-facing transparency tools, which differentiates it from prior blockchain-based supply chain models [27]. Unlike traditional luxury-focused authentication frameworks, such as VeChain's RFID-based tracking for luxury goods [10], this model is scalable across the fashion industry, including fast fashion and ethical production [12]. Furthermore, while prior research has assumed that blockchain's benefits are self-evident, our findings highlight gaps in consumer awareness and trust, emphasizing the need for education, usability, and perceived relevance in blockchain adoption [32]. To clarify how these findings extend or contrast with existing literature, Table 8 summarizes the key theoretical and managerial contributions of this research.

6.2. Theoretical and Practical Implications of the Research

Conducting the acceptance study was a key part of our model, with its aim being the identification of factors influencing the adoption of blockchain technology among end-users in the fashion industry. This study comprehensively analyzes various variables, concepts, and models to demonstrate customers' readiness to engage in buying fashion products authenticated by blockchain technology. Theoretical and practical implications of the research are shown in Table 9.

Table 8. The key theoretical and managerial contributions of the proposed model.

Existing Model	Focus	How the Proposed Model Differs
VeChain-Based Fashion Authentication [10]	Use RFID and NFC chips linked to blockchain to track product authenticity.	The proposed model goes beyond physical tracking by incorporating consumer engagement, e-commerce integration, and an end-to-end supply chain approach.
Everledger Fashion Lifecycle Tracking [71]	Focus is on high-end luxury product lifecycle tracking using blockchain.	The proposed model extends beyond luxury brands and includes fast fashion and ethical production tracking, making it more versatile.
IoT–Blockchain Integration for Fashion [21]	Use IoT sensors to log real-time product conditions (temperature, handling).	This model focuses on physical conditions, whereas the proposed model enhances supply chain transparency, smart contracts, and consumer trust mechanisms.
Blockchain for Sustainable Fashion Supply Chains [12]	Evaluate blockchain's role in ensuring ethical sourcing and sustainability.	While sustainability is a feature of the proposed model, it integrates broader adoption factors like smart contracts, e-commerce, and user acceptance.

Table 9. Theoretical and practical implications of the research.

Key Theme	Findings from This Study	How this Extends or Differs from Existing Studies	Implications
Consumer trust and blockchain adoption	Consumer trust is a major driver of blockchain adoption in fashion retail.	Existing studies focus primarily on technical barriers to blockchain adoption [11]. Our study expands this by highlighting behavioral trust as a crucial factor.	Brands should promote trust-building mechanisms, such as certified blockchain product verification and transparent data-sharing with consumers.
Technology acceptance and usability	Effort expectancy and perceived usefulness are key factors influencing adoption.	Prior research on blockchain adoption assumes functional efficiency is enough [27], but our findings suggest ease of use is equally critical for consumer engagement.	Blockchain applications in fashion should be user-friendly, reducing complexity in authentication and product tracking interfaces.
Consumer awareness and adoption barriers	Consumer awareness and perceived relevance of blockchain in fashion retail remain low.	Unlike studies assuming blockchain's benefits are self-evident to consumers [32], our study shows that education gaps significantly hinder adoption.	Fashion brands need awareness campaigns to educate consumers on blockchain's practical value, such as sustainability tracking and counterfeit prevention.
Proposed adoption model contribution	The study introduces an extended UTAUT2-based model, incorporating trust and perceived relevance for blockchain adoption in fashion.	Existing blockchain adoption models do not fully consider trust as a primary consumer concern [28]. Our model provides a more holistic framework.	Future research should test and refine this model in different fashion market segments, ensuring applicability across diverse consumer bases.
Brand strategy and market integration	Brands should position blockchain as a trust-enabling tool rather than just a supply chain innovation.	Prior studies emphasize blockchain's efficiency and fraud prevention, but our findings show that consumers value ethical sourcing and transparency more [29].	Blockchain should be framed as a means to strengthen brand integrity, rather than just a technical solution.
Regulatory and industry collaboration	Strategic collaborations with retailers and regulators can accelerate blockchain adoption.	While blockchain offers decentralization, regulatory clarity and partnerships are needed to encourage adoption [28].	Fashion brands should collaborate with governing bodies and industry coalitions to establish blockchain authentication standards.

Using established theoretical models such as the Unified Theory of Acceptance and Use of Technology (UTAUT2), we designed a comprehensive survey and analyzed the collected data. The results showed that expected effort, perceived efficiency, and social influence significantly impact the adoption of blockchain technology among end-users. End-users are particularly concerned with the usability of blockchain systems and the perceived security of their transactions. These findings underscore the importance of developing user-friendly interfaces, implementing robust security measures, and conducting educational campaigns to enhance consumer trust and readiness to adopt this technology. The insights gained from this acceptance study contribute to the theoretical models of technology adoption while highlighting the role of expected effort, perceived efficiency, and social influence in the adoption process.

The results of this research have practical significance for all participants in the fashion industry supply chain. Designers can ensure the integrity and authenticity of their products, thereby enhancing the brand's reputation and consumer trust. Suppliers benefit from blockchain's ability to track and verify the entire production process, ensuring product quality and compliance with industry standards. Distributors can use blockchain to verify product authenticity before distribution, reducing the likelihood of counterfeit products entering the market. To operate these insights, we intend to develop a decentralized application (dApp) specifically designed for small and medium-sized fashion enterprises. The application will incorporate blockchain-enabled provenance tracking, supplier verification mechanisms, and automated payments via smart contracts, alongside a user-facing interface that enables product authentication through QR code scanning. A pilot implementation will be conducted in collaboration with selected partner fashion houses, whose evaluation of the application's usability, functional effectiveness, and potential technical or organizational barriers will inform iterative refinements prior to broader deployment.

Authentication via blockchain can help retailers build trust with consumers by offering verifiable product information and origin details, leading to increased customer satisfaction and loyalty.

Finally, end consumers can make informed decisions by relying on clearly accessible information.

6.3. Research Limitations

The research presented in this paper also has its limitations related to the target group of respondents, which primarily consisted of younger individuals who were already familiar with online shopping and interested in fashion trends. In addition to real-world implementation challenges, another limitation is the current focus on consumer perspectives in model validation. To ensure a more comprehensive evaluation, future studies should incorporate conceptual validation through focus groups and expert interviews with fashion brands, technology providers, and logistics companies. This approach would provide insights into the feasibility and technical adaptability of blockchain solutions before full-scale implementation.

Although this group represents an important segment of consumers for assessing the readiness to introduce blockchain technology in the fashion industry, a broader and more diverse population would provide a more comprehensive insight into the general attitudes and perceptions of this technology. Many studies on blockchain adoption in the fashion industry face significant limitations due to unbalanced or narrow data samples, often overrepresentation of younger, tech-savvy, and highly educated respondents while underrepresenting general consumers and older demographics [11,28]. Some studies focus on industry stakeholders, such as manufacturers and supply chain operators, rather than consumers themselves, which may overlook end-user perspectives [94]. Even large systematic reviews acknowledge sample selection bias and publication bias as challenges in constructing representative datasets [95].

Similarly, the demographic characteristics of our research sample introduce certain biases that may have influenced the results and limited their generalizability. The age distribution was heavily skewed toward younger generations, with 55.6% of respondents aged between 20 and 25, corresponding to Generation Z (born 1995–2012). As digital natives, this generation tends to be more technologically literate and open to innovations such as blockchain. In contrast, older generations—including Millennials (born 1981–1996) and especially Generation X (born 1965–1979), who may be more skeptical toward new technologies—were significantly underrepresented. This imbalance likely contributed to an inflated perception of consumers' readiness to adopt blockchain-authenticated fashion products.

The gender distribution, with 63.1% of respondents identifying as female, reflects the reality that women are the dominant consumers in the fashion industry. However, while this aligns with industry demographics, it may have also shaped the findings, as female consumers are often more engaged in ethical sourcing, authenticity, and brand transparency. A more balanced gender sample could have revealed whether male consumers prioritize different factors in blockchain adoption.

The education level of the sample was also skewed, with 48.1% holding a university degree and 17.4% having postgraduate education. Highly educated individuals are more likely to understand blockchain and its benefits, leading to more favorable responses. This does not necessarily reflect the attitudes of consumers with lower education levels, who may find blockchain adoption less relevant or accessible.

The employment status of respondents, where 56% were students, may have introduced a bias regarding financial considerations. Students have different spending habits and lower purchasing power than working professionals, potentially misrepresenting how price-sensitive consumers perceive blockchain-authenticated fashion products.

Finally, the high familiarity with blockchain technology, reported by 72.6% of respondents, represents another limitation. Consumers already aware of blockchain are more likely to view it positively. In contrast, general consumers, many of whom are unfamiliar with blockchain, may be more hesitant to adopt it, making the study's results more optimistic than reality.

One of the key limitations of this study is the difficulty in validating the proposed model in real-world conditions, primarily due to the challenge of collaborating with major fashion industry players and gaining access to their entire supply chains. Blockchain authentication requires seamless integration across multiple stakeholders, including manufacturers, suppliers, logistics providers, retailers, and end consumers. However, large fashion companies often operate within highly fragmented, competitive, and opaque supply chains, making it extremely difficult to obtain the level of access needed for full-scale testing. Many companies are reluctant to share proprietary data, implement new systems, or disrupt existing supply chain operations, further complicating real-world validation. While simulations serve as an initial proof of concept, they cannot fully capture the logistical, technological, and organizational challenges of industry-wide implementation. To bridge this gap, we plan to develop a functional prototype based on insights from our study, allowing for a more practical assessment of the model's feasibility. This prototype will serve as a stepping stone toward real-world adoption, helping to identify and address barriers to collaboration before engaging with major industry players.

6.4. Future Work

Plans will focus on expanding the proposed model and conducting additional UTAUT studies that will cover a larger and more diverse population. Before the development of the decentralized application (DApp), conceptual validation will be conducted through stakeholder engagement, including interviews and surveys with fashion brands, suppliers, and technology providers. This will ensure that the blockchain-based system aligns with industry needs and technical requirements before real-world deployment.

As part of these efforts, a decentralized application will be developed based on the proposed model and insights from this study, using platforms such as Ethereum and programming in Solidity. To ensure a more practical validation, the application will first be tested within a smaller real-world system, allowing assessment of its feasibility before engaging with large-scale industry stakeholders. AI will be utilized for smart contract automation, customer behavior analysis, and real-time data processing from IoT devices. The application will connect the blockchain network with a cloud database for secure information storage and sharing among key industry stakeholders: designers, manufacturers, suppliers, distributors, and retailers. Additionally, a multi-currency payment system and a specialized supply chain transparency dashboard will be implemented to further enhance trust in the system. These future activities aim to refine the accuracy and comprehensiveness of our findings while providing deeper insights into the opportunities and challenges of blockchain adoption in the fashion industry.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Classification of questions by constructs from the UTAUT2 model.

MODERATING VARIABLES	
Age	How old are you?
Gender	What is your gender?
Education	What is your level of education?
Role/Status	What is your current status?
LATENT VARIABLES/INDEPENDENT VARIABLES	
Expected Effort	1. Are you aware of the specific conveniences that the application of blockchain technology offers in the fashion production process?
	2. On a scale of 1–5, rate how easy you think it will be for you to opt for fashion brands where you always have insight into the entire supply chain and the product lifecycle.
Perceived Risk	1. On a scale of 1–5, rate your awareness of the growing problem of counterfeit fashion products available on the market.
	2. Is it important to you that only an authorized person representing a fashion brand can access your data?
	3. Is it important to you that your personal data provided during online shopping is never lost, altered, or misused?
	4. On a scale of 1–5, rate how much it bothers you that designers brand cheap low-quality products as their own and sell them at higher prices?
	5. On a scale of 1–5, rate how much it bothers you that designers brand other designers' products as their own and sell them more expensively without crediting the original creator?
Social Influence	1. On a scale of 1–5, rate how often you shop online through a brand's website or mobile app.
	2. On a scale of 1–5, rate how much you agree with the statement: "I would follow online activities more often via website or mobile app if I knew all this information about each product."
Perceived Efficiency	1. On a scale of 1–5, rate how much you agree with the statement: "This technology would make the shopping process easier and positively influence my choice."
	2. On a scale of 1–5, rate how much you agree with the statement: "If this technology becomes prevalent in the future, it will enable all consumers to have a faster and simpler selection process for clothing items."
Price value	1. On a scale of 1–5, rate if faced with a wide assortment of products from different manufacturers, would you rather opt for quality regardless of the price?
	2. On a scale of 1–5, rate how much you agree with the statement: "I would invest more attention and money in fashion brands that guarantee me quality and security during online payments."
	3. On a scale of 1–5, rate whether you would be willing to pay more for a clothing item if you are certain of the material's origin and the quality of the product itself.
	4. On a scale of 1–5, rate how much you agree with the statement: "When shopping, I do not pay attention to the price of products."

Table A1. *Cont.*

	MODERATING VARIABLES
Facilitating Conditions	1. On a scale of 1–5, rate how much the availability of information about the designer or fashion house, the origin of materials, the maintenance of the product, the place where the product is made, and quality control would influence your purchasing decision.
	2. On a scale of 1–5, rate if you prefer online shopping, how important is it that your chosen fashion brand has a loyalty program through which you can transparently track discount points?
	3. On a scale of 1–5, rate if you would like to have information about the manufacturing process of the product you are buying and all the processes it goes through.
	4. On a scale of 1–5, rate how important you consider having information about the origin and type of material from which the product is made.
Habits	1. On a scale of 1–5, rate to what extent you take care that the products you buy have a declaration with truthful data.
	2. On a scale of 1–5, rate how much you agree with the statement: "If a product is heavily discounted, I do not pay attention to the quality of the product itself."
	3. On a scale of 1–5, rate how much you agree with the statement: "Before I decide to buy a product, I always pay attention to the information about the product that is on the declaration."
Trust	1. On a scale of 1–5, rate whether you trust online payment for products.
	2. On a scale of 1–5, rate how often you have been in a situation where due to lack of information about the product, you were not satisfied with your online purchase.
	3. On a scale of 1–5, rate whether and to what extent you believe that your personal data is protected within the websites and mobile applications of various fashion brands.
	DEPENDENT VARIABLE
Expected Behavior	1. On a scale of 1–5, state that the implementation of blockchain technology would result in increased security and accuracy of information about a product.
	2. On a scale of 1–5, state that the implementation of blockchain technology would result in significant time savings, both for consumers and other interested parties.
	3. On a scale of 1–5, respond how much you agree: "I intend to buy clothes from fashion brands that will offer me more information and greater security."
	4. On a scale of 1–5, respond how much you agree: "I intend to recommend to friends the use of websites of fashion brands that have such services."

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