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Application of Blockchain in RMG Supply Chain: A Literature Review

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Abstract - ***The*** **Bangladeshi Ready-Made Garments (RMG) sector faces higher lead times than competitors, making supply chain efficiency crucial for global competitiveness. Blockchain technology, first introduced by Nakamoto in 2009, offers a potential solution by encoding transaction data, reducing operational costs, and enhancing decision-making. Its application in the RMG supply chain could improve production speed, logistics, and stakeholder coordination while minimizing delays. Moreover, blockchain supports circular economy models by reducing environmental damage, ensuring compliance, and enhancing transparency. It also helps mitigate the bullwhip effect, preventing overproduction and inefficiencies. For Bangladesh, a global RMG leader, adopting blockchain would build trust with Western buyers through verifiable standards and lead to repeat orders and long-term competitiveness. Based on secondary sources like JTSE and JBMER, this research highlights how blockchain integration has benefited other industries and how the RMG sector can similarly gain transparency, sustainability, and performance.**

Keywords - **Blockchain, Supply chain, Ready-Made Garments, RMG**

I. INTRODUCTION

Bangladesh's ready-made garment (RMG) sector has grown to be vast. It acts as the inciting agent for the expansion and advancement of the economy. The industry is the primary source of income for Bangladesh's exports. The country's low labor costs are the main reason for its dominant position in the global RMG market [1]. Nevertheless, the industry cannot keep up with the quick changes in consumer demands. Lead time is now only 90 to 100 days compared to 100 days in the 1990s. This is insufficient considering that rivals like China can deliver goods in thirty to thirty-five days. Other competitive nations have improved their supply chain networks so that they can react faster to changes in the market [3]. Additionally, the RMG sector in Bangladesh is currently having difficulties with cost, quality, and customer service. A large number of well-known purchasers from various nations throughout the world are engaging in simultaneous trade with other countries. Since raw materials are easily accessible in some parts of the world and cheap labor is available in others, globalization has become the norm. Furthermore, several time-sensitive factors, such as cost, time, and quality sensitivity, differ greatly amongst clients on different continents. One could argue that Bangladesh could become competitive by implementing integrated supply chain management. To be competitive, one must guarantee the necessary responsiveness and efficiency in the supply chain [1].

A supply chain is the sequence of events that includes all the facilities, operations, and activities involved in creating and transporting a good from supplier(s) to customer(s). As a traditional management tool, supply chain management enables manufacturers to work toward increasing the quality of their products, lowering the cost of their goods and services, and speeding up product delivery and response times in a highly competitive market. Retailers, distributors, suppliers, and customers are all part of the supply chain that work towards achieving a common goal [2].

An effective supply chain system lowers inventory and operational costs through efficient material planning, shortens order cycle times, lowers logistic costs, increases asset productivity, and makes a company more profitable. Effective supply chain management enables the apparel manufacturing sector to respond quickly [4]. Although various researchers classify the activities that make up a supply chain differently, these processes are largely functionally independent and fairly comparable in that regard:

a. Forecasting demand based on market research,
b. Placing and receiving customer orders,
c. Managing inventory,
d. Planning production,
etc. Communicating between supply chain partners
. Managing distribution (shipping)

Forecasting is the basis for all strategic and planning decisions in a supply chain, i.e., production, scheduling, inventory, aggregate planning, and marketing: sales force allocation, promotions, and finance: plant/equipment investment, budgetary planning. [6].

It is believed that applications of blockchain technology have the potential to revolutionize the apparel industry, as well as the hardware and supply infrastructure that goes along with it. In contrast to the conventional legacy systems currently in use in the apparel industry, the underlying technology and the corresponding cryptocurrency with its decentralized architecture suggest a range of applications that can bring cost savings. The underlying Information Technology (IT) architecture and its "unbreakable" chain of data entries, which permit safe and transparent transactions, are the core promises of the blockchain. An auditable distributed ledger that makes every transaction visible to everyone is made possible by a decentralized and distributed blockchain data database, allowing an efficient and effective supply chain management [5].

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II. LITERATURE REVIEW

In 2009, Nakamoto first put forth the idea of blockchain technology (BCT). He described this idea as a technology that develops data structures and encodes information transactions using Bitcoin and data mining techniques. A blockchain's data will be permanently saved online with extreme security and transparency. The fundamental components of blockchain technology are a decentralized network that is cryptographically secured and an immutable distributed ledger. Through peer-to-peer replication, the blockchain architecture enables participants to share an updated ledger each time a block of transactions is decided to be committed. The immutable transformation records that blockchain technology produces, the near-instantaneous updates to transparent ledgers, and the reduction of operational costs and friction are all made possible by this technology. It may also create new avenues for innovation and expansion and fundamentally alter how business processes and workflow are planned inside an organization [15].

One of the most critical sectors in the world, the fashion industry generates more than $450 billion in sales worldwide. It has also been demonstrated to be the most environmentally damaging industry, and there has been constant pressure to switch to a more circular economic (CE) model. The fashion industry's shift to CE incorporates ideas like upcycling and recycling materials and products, and a key obstacle is ensuring that values are aligned throughout the supply chain, especially with those of the customer. Consumers' growing concern towards sustainability has led to the popularity of upcycling and materials recycling. In the fashion industry, customers usually only know what goes on at the retail level and don't know much about how their purchases affect other people and other supply chain links. BCT is a valuable tool for improving the alignment between consumer values and demand and the interests of different supply chain participants by increasing the transparency of practices and processes throughout the chain, which can lead to adopting a CE model [12].

Issues about the apparel supply chain include new orders, the supply of raw materials, production procedures, and logistics associated with the delivery of finished goods. Bangladesh's garment industry needs to improve to shorten the time it takes to produce and fulfill orders from overseas businesses. According to research, utilizing contemporary, quick, and efficient machinery can shorten the time it takes to deliver the order [9]. SCM often aims to link, if not centrally control, a product's assembly, shipment, and distribution. Businesses are prepared to reduce unnecessary expenses and expedite product delivery to customers by effectively managing the supply chain. This is frequently accomplished by maintaining stricter control over internal production, sales, distribution, and inventory, as well as the inventories of company vendors.

SCM is based on the idea that nearly every product sold results from the labor of several companies that put together a supply chain. Supply chain management has been around for a long time, but most businesses are only now starting to pay attention to it to improve their operations. Enhancements in output and effectiveness directly affect a company's bottom line and have a genuine, long-lasting effect. Effective supply chain management keeps businesses out of the news and out of costly recalls and legal trouble [7].

Despite initial concerns about potential adverse effects following the removal of quotas (the Multi-fiber Arrangement (MFA) in global trade in apparels and textiles was phased out in December 2004), the RMG sector in Bangladesh is showing signs of growth, as evidenced by the significantly higher rate of export amount, the number of jobs and industries, and GDP growth [10]. The supply chain performance in Bangladesh's apparel industry is below the global average, and the country's manufacturing and retail sectors lack industrial benchmarks and a general understanding of supply chain management. As competition in domestic and international business sectors rises, many businesses and service providers have realized that supply chain management requires more strategic approaches. The development of traditional SCM systems up to the cutting-edge systems that companies use today was subsequently influenced by these effective factors and their realization. The 1990s saw the development of supply chain management; during this time, traditional approaches to supply management functions were improved through manufacturer-supplier collaboration. Wholesalers and retailers combined their logistics operations to gain a more potent competitive edge [8].

The business landscape has evolved in the twenty-first century, so collaborating with upward and downward supply chain partners is more profitable than working alone. Businesses aim to offer customers the most value for the goods or services they receive through supply chain management, which is accomplished through achieving efficiency or responsiveness. Manufacturers should plan and collaborate with the downstream buyers, supply chain partners, and upstream fabric and accessories suppliers to improve supply chain performance and give the RMG sector more dynamic capability [11].

Table I: Potential Blockchain Application

Author (yr)	Focusing Area	Application Field
Van Hoek 2019	RFID implementation framework for blockchain in the supply chain	Supply Chain
Martinez et al., 2019	Blockchain for resource and information processing	
Apte and Petrovsky, 2016	Verification of material ingredients	
X. Y. Wu et al., 2021	Blockchain-based traceability system	
Kumar et	Blockchain-integrated	

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al., 2021	vaccine supply chain architecture	
Beinke et al. 2018	Cross-border transaction without currency exchange fees	Finance
Wang and Kogan 2018	Strengthening accounting, auditing, and bank transfer	
Nowiński and Kozma 2017	Reducing transaction costs	
Kowalski et al., 2021	Developing a trust relationship in trade finance	
Bocek et al., 2017	Storing and accessing medical products	
Palma et al., 2019	Safe academic record and automatic degree issuance after course completion	Higher Education
Vidal et al., 2020	Blockchain-based assessment of learning outcomes	
Griffey 2016	Unique identity and transferability of digital documents	
Mori et al., 2019	Data encryption and security	
Kumar, Upreti, Raut, et al., 2021	Blockchain for data integrity	

Supply chain configurations can use blockchain technology in various ways [13]. One of the main applications of blockchain in the textile and apparel industry is the tracking of materials and products through different manufacturing stages, from initial raw material management to finished goods management. Blockchain promises that, in the case of a fashion product manufactured from eco-friendly materials, it will not require any additional certifications or inspections. Once stored in the blockchain system, the data is permanent and accessible to the public. This becomes crucial because it becomes more challenging to hold fashion companies accountable for the conditions under which their clothing is made and their sustainability pledges when supply chains lack transparency. Concurrently, consumers and industry participants express a greater desire for more sustainably and ethically produced goods. A study by Morning Consult found that 64% of participants would purchase a garment if it could use new technology to support its claims about sustainability. It is essential to research blockchain operations while keeping in mind its applications and supply chain requirements because supply chains across various industries vary significantly in terms of their features and functionalities [17]

There are several blockchain initiatives in the clothing and textile sector. Through recording data on product ownership, material processing, and material movements as the product moves through the supply chain, blockchain has been used to identify and track the provenance of goods. As a digital twin of the supply chain, permanent product records and associated data are kept on the distributed ledger enabled by blockchain technology. We separate two main application areas from the existing blockchain applications in the textile and apparel industry: (a) Use of blockchain technology to guarantee product authenticity. Numerous blockchain pilots have been motivated by the need to combat fraud and ensure the authenticity of products, particularly for luxury brands that produce high-end goods. The traceability solution begins at the point of final product creation in most of these pilots. In addition to producing high-sustainability fiber, some manufacturers use technology to combat counterfeiting and authenticate their fiber. Examples of these blockchain pilot programs in particular companies' supply chains are Chargeurs Luxury Materials, Lenzing, and Hugo Boss [13]. To guarantee the sustainability of their products, some retailers and brands have investigated or tested blockchain technology, such as Armedangels, C&A Foundation, and Martine Jarlgaard. To comply with environmental and social sustainability regulations and showcase sustainable practices to their clientele, businesses must ensure that the manufacturing and distribution processes are traceable and transparent, and all parties involved are identified. Moreover, blockchain offers environmentally sustainable solutions for the fashion apparel manufacturing industry to lower carbon emissions in all critical steps of clothing making. These characteristics include decentralization, transparency, automation, and immutability. Through blockchain-enabled circular supply chain management in the fast-fashion industry, blockchain may help to develop a sustainable circular economy. Blockchain shows great promise in solving the issue of infringement in the fashion industry [14].

The best-positioned fashion companies to survive such a competitive market will be those that can adjust to growing complexity by changing their operating models and supply chain, sales channel, and digital marketing strategies. Although BT has been applied in several industries, the literature suggests that the textile and fashion industries have not given enough thought to blockchain adoption. Over the past few years, blockchain has been given more and more consideration for various applications in the textile and fashion industries, from supply chain management and tracking to smart contracts, product authentication, and payment processing. Nevertheless, there is still a dearth of empirical data on the motivations, locations, and strategies businesses use to integrate this technology into their supply chains [15].

IV.METHODOLOGY

The secondary data used in this study's analysis

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includes papers from conferences, journals, digital libraries, and other sources. Numerous academic and professional research papers on the textile industry have been compiled from various reputable international journals, including IJBER, IJSCM, JTSE, IJTS, JBMER, AJBMS, and others. The textile and apparel industries were chosen for this study based on several criteria. First off, the industry's blockchain technology experimentation is progressing quickly. Second, this industry differs significantly in terms of supply chain configuration, product attributes, and business process characteristics, as well as in the regulatory frameworks and market conditions in which it operates. Thirdly, because there are so many social and environmental problems, sustainable development is one of the most challenging sectors. Production, shipping, and logistics are essential for managing material flows across intricate and international supply chains. They are also highly fragmented and globalized and must adhere to several rules, business procedures, and management requirements.

V.DISCUSSION

A recent investigation into the potential impact of blockchain technology on supply chain practices and policies identified the primary drivers of blockchain deployment within supply chains and the areas in which this emerging technology may offer the most outstanding value for supply chain management. A noteworthy finding regarding blockchain endeavors is that most technology companies utilize permissioned blockchain solutions. This is not surprising considering how sensitive supply chain information is—it is not a good idea to divulge confidential information to unidentified parties at any stage of the supply chain, including demand, capacities, orders, and prices. Additionally, permissioned blockchains are better at maintaining the consistency and integrity of data appended to the blockchain—a crucial feature for making decisions. In a blockchain-based supply chain network, there usually is a network orchestrator— possibly one of the funding members—who helps the various stakeholders coordinate and work together. This orchestrator is essential to the creation, appropriation, and distribution of value among network participants in the future. Specific consortia aim for more than just socioeconomic benefits. The blockchain facilitates transactions between various supply chain participants without needing an intermediary. As a result, it appears to work best when a problem affects several parties and solving it will benefit each of them. Participated members are motivated to collaborate and encouraged by this shared value [18].

Sustainable solutions are desperately needed in many industries, but the textile sector is one of the most urgent. Increasing traceability and transparency is a necessary first step towards implementing sustainable solutions, and blockchain technology can help with this. Through proactive system design, blockchain can improve traceability, sustainability, and transparency, allowing all parties involved in the supply chain to assess the effects of their actions over their entire life cycle and make more intelligent, strategic procurement decisions that are proactive rather than reactive. Concurrently, barriers for secondary markets are being lowered, and consumers can embrace better consumption, maintenance, and disposal practices by using blockchain technology. It makes it possible for the sector to more effectively and expeditiously comply with current and upcoming regulations. The textile sector requires a proactive approach to handle present and upcoming regulatory obligations.

Early adoption of blockchain technology by textile retailers will make them more resilient to disruptions in the industry, allowing them to track their entire supply chain and guarantee compliance at all levels. Policy makers will pressure organizations to address data security and traceability; those that do not act quickly to implement solutions risk noncompliance or expulsion from the market. Additionally, customers will want assurance that their clothing is made in more environmentally and socially friendly ways, and they might not be willing to pay for items that do not meet higher standards in the future due to the increased information transparency and credibility afforded by blockchain. Therefore, implementing traceability solutions immediately is in everyone's best interest. Blockchain is the most outstanding technology for safely tracking and managing every variable in this intricate supply chain. Governments can proactively mitigate environmental risks when foreign practices contradict domestic policies [19].

Overproduction can be decreased by using blockchain technology. There is a bullwhip effect because the fast-fashion supply chain is linear (design-manufacturing-sale-disposal). Due to the linear structure, information about end-customer demand must be distorted (primarily amplified for buffer consideration) when going upstream to suppliers, as only two adjacent nodes have the proximity to share information in part. As a result, the linear system produces significant waste due to transit inventory and overproduction. To lessen the bullwhip effect, a conventional approach has been to look for centralized information on consumer demand; however, this necessitates open communication among supply chain participants. However, this is challenging in a system beset by "lacks," such as a lack of mutual trust, a lack of a common goal among supply chain participants, and incomplete information sharing in multi-tier supply chains. In addition to that, supplier management and supplier selection using blockchain technology can help address the challenge of environmental and social responsibility. One of the most crucial choices in the pre-production phase for attaining sustainable supply chain management (SCM) is the assessment and choice of sustainable suppliers. Fast fashion companies must locate dependable and trustworthy suppliers, particularly those with sustainability certifications, as many of their production activities have been outsourced to low-wage nations. In the past, fashion outsourcing companies have independently developed a multi-criteria selection process that may or may not take social and environmental sustainability into account. The recycle/reuse/reduce option is the most critical factor in environmental protection when choosing and evaluating suppliers. In the meantime, child/forced labor, health and

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safety, freedom of association, discrimination, disciplinary procedures, working hours, compensation, and management systems are all covered by the Social Accountability 8000 (SA8000) standard certification (Social Accountability International, 2014). To receive certification, suppliers must fulfill all of these prerequisites (Witkowska, 2016). As a result, evaluating and selecting suppliers is intricate and time-consuming, involving numerous actors, procedures, and pieces of data.

Blockchain technology may offer a more advantageous choice when assessing and choosing the best suppliers. Before a prospective supplier is allowed to access the blockchain, it must be validated. Blockchains can be programmed to automatically trigger actions (including supplier certification) once specific conditions are met, and they can accelerate the flow of data between nodes due to the inherent characteristics of automation. As a result, all blockchain nodes can quickly conduct, record, and access the verification. Consequently, a blockchain-driven supplier selection procedure will be simpler, faster, and more reliable to ensure a successful launch of CSCM during the pre-production phase. Blockchains can precisely record, trace, and monitor peer-to-peer asset transactions. As a result, the blockchain record and traceability system can assist in promoting the three pillars of sustainability by tracking and monitoring environmental and social responsibilities in real-time.

In addition to auditing manufacturing from biological sources and technical fibers derived from non-renewable chemical resources, it can, for instance, audit the quality and safety of using chemicals, water, and land during the fashion production. Gathering information about the light, humidity, temperature, and working hours at the workplace can also determine the status of the workforce and the working conditions. These data can be used to analyze, assess/reassess, and certify/recertify whether the suppliers have complied with the obligations and moral standards to treat their workers fairly during manufacturing. Many fast-fashion items are currently regarded as waste and thrown away in the post-production phase, even though they are still in reusable condition, after being worn a few times or never even being sold. Blockchain technology can make recycling and reusing these fashion items easier in the right contexts. The production and usage history of items can be easily tracked and authenticated since the blockchain has verified and recorded information about the fashion product (such as brand, model, manufacturer, components, processing technology, purchasing date) and even the consumer. These used goods can be given away, rented out, or sold again after being cleaned and sanitized to increase their useful life. Depending on where the clothes are reused, buying 100 secondhand clothes could prevent the production of 60–85 new ones. This shows how blockchain technology applications can benefit CSCM in the fashion industry. Furthermore, materials from products acknowledged to be nearing the end of their useful lives can be recycled into new products via blockchain verification and authentication. For instance, post-consumer textile waste can be used to create purses, hang tags made of polyester, and bow ties. Particle boards, decorative bowls and vases, and other sustainable composites can be made from the blended fabrics. As a result, blockchain technology can reduce the quantity of textile waste dumped in landfills and save resources needed to create products and production lines [12].

While taking the example of Lenzing (which produces wood-based viscose fibers, modal fibers, lyocell fibers, and filament yarn, which are used in the textile industry — in clothing, home textiles, and technical textiles — as well as in the nonwovens industry), it fights counterfeiting. Utilizing the blockchain solution guarantees the authenticity of their sustainable fibers in the finished clothing. Lenzing's downstream complex supply chain has made identifying and tracking fiber easier through blockchain technology and embedded tracers. In addition, the blockchain-based platform facilitates safe information exchange between the geographically separated supply chain partners. It offers a single data source from which participants can obtain, exchange, and verify their sustainability certifications and supply chain data. Lenzing can ensure its sustainable fibers are used sustainably by exchanging certifications and sustainability-related data. This also holds significance for retailers and end brands, as they can utilize the blockchain platform to ascertain the sustainability credentials of every supplier within their network. To guarantee the authenticity of the traceability data and to confirm the connection between the real and virtual worlds, it is still essential to employ a third-party auditing company to validate the data collected on the blockchain platform throughout the supply chain. We contend that future strategies and standards to enable supply chain traceability through blockchain technology will heavily incorporate external audits [13].

Moreover, it is demonstrated that behavioral intentions and purchase behavior are significantly correlated. In addition, the intention to purchase an online product is predicted substantially by attitude, perceived usefulness, and ease of use. The most crucial role of technology is to foster a positive attitude toward its adoption. Marketers should promote this attitude through deep product knowledge, a strong brand image, and enhanced customer communication. Marketers ought to inform customers about blockchain technology's positive effects on the environment and how it can improve both their own and future generations' lives. Generations to tackle the COVID-19 issues. Research verified that perceived utility and perceived usability play a significant role in influencing behavioral intentions to use blockchain-enabled online ordering systems, consistent with earlier theories of TAM. Additionally, the results validate the perspective that consumers value blockchain's use in an online system for product purchases. Creating new styles and adapting to the rapidly shifting needs of customers are not the only two challenges COVID-19 has brought about for the world's apparel industry.

"Counterfeiting" is a significant issue undermining the luxury clothing and fashion sectors. The most prominent players in the market invest millions of dollars in starting a

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new trend. Still, when it comes to making money, dishonest manufacturers and traders enter the fray and steal a significant portion of the earnings by providing low-cost replicas of clothing and accessories. While there are several ways to stop someone from leaving a store with stolen clothing, counterfeiting is another animal. The underlying data, which shows that counterfeit goods cost the clothing and fashion industries more than $1000 billion annually, illustrates the seriousness of the situation. The alarming aspect is that counterfeiting has worsened, even with stringent government laws. Imagine how simple it would be to trace clothing from the material used to make it to when it was purchased online or in a store. For consumers, what would that mean? Using smartphones, consumers can verify the legitimacy of a product before purchasing by scanning the barcode on a shirt, pair of pants, or another item. Transparency and traceability will result from having access to information about where it was made, which raw material was used, and other details. Customers will confidently choose the product they want to purchase on their own.

Because a blockchain will allow brands to hold and control the data they provide to their employees and the outside world while adhering to necessary ethical standards, there will be no room for copying and creating duplicate goods. After COVID-19, using blockchain will improve customer relations and increase revenues. Additionally, thanks to this, customers can comprehend the intricacy of bringing a product to market. This may change the way they view purchasing comparable but less expensive goods. Rather than restricting themselves to disposable items and concentrating solely on cost-cutting measures, the apparel and fashion industry can now emphasize quality and sustainability without compromising margins and revenues, thanks to increased buying and sales figures [14].

V. CONCLUSION

The discourse on the ready-made garment (RMG) sector in Bangladesh and its intersection with supply chain management and blockchain technology is a comprehensive exploration of the challenges and opportunities faced by this vital sector. The RMG industry, a cornerstone of Bangladesh's economy, has witnessed significant growth, primarily fueled by the country's low labor costs. It faces challenges such as inadequate responsiveness to changing consumer demands, extended lead times compared to global competitors, and price, quality, and customer service issues. Effective supply chain management (SCM) is an essential strategic imperative for the RMG sector.

There is an urgent need for sustainable solutions in the textile industry and blockchain to be positioned as a catalyst for traceability, transparency, and environmentally conscious practices. The paper forecasts the potential for blockchain to mitigate overproduction through decentralized and transparent systems and its role in supplier management, selection, and addressing environmental and social responsibilities.

Blockchain technology has the potential to integrate with the infrastructure of the textile RMG supply chain and disrupt the industry for the betterment. Blockchain's decentralized architecture, cryptographic security, and immutable distributed ledger position it as a disruptive force capable of addressing critical issues such as counterfeiting, traceability, and transparency within the textile and apparel supply chain. Blockchain integration is presented to align consumer values with sustainable and ethical practices, fostering a more transparent and accountable industry.

We envision blockchain technology as a game-changer for the apparel industry, offering operational efficiencies and a paradigm shift towards sustainable and ethical practices. The adoption of blockchain is portrayed as a strategic move to meet evolving consumer expectations, navigate regulatory obligations, and ultimately enhance the resilience and competitiveness of the RMG sector in Bangladesh and the broader global fashion industry.

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