Original Article

Remodeling the Traditional Fashion Industry in the Era of Industry 4.0

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Abstract: This study examines the influence of Industry 4.0 on the global garment design business and investigates methods for transforming conventional industrial procedures. The report utilizes the opinions of experts, academics, and industry professionals to identify obstacles in the traditional clothing sector. It suggests ways for businesses to use innovative technology and gain a competitive advantage. The method includes a complete literature review of relevant studies over the past 20 years, focusing on how new technologies related to Industry 4.0 are used in the garment industry. The Internet of Things (IoT), artificial intelligence (AI), big data analytics, and cloud computing are included. The report also looks at what is being done to help the garment industry deal with problems as it moves to Industry 4.0. The results show that Industry 4.0 technologies have the potential to improve production efficiency, lower costs, make customers happier, boost sales, update employees' skill sets, and make the company more competitive. The study makes several recommendations for apparel companies to modernize their operations, such as leveraging digitalization to facilitate rapid response in the supply chain, utilizing personalization and innovative design to enhance products, and meeting shifting consumer demands through customization.

Keywords: Industry 4.0; Traditional industry practices; Advanced technologies.

1. Introduction

Industry 4.0, the fourth industrial revolution, is a technical development and digitization. The German government initially launched the notion in 2011 to modernize the nation's industrial sector and boost its competitiveness by using the possibilities of digital technology (Bertola & Teunissen, 2018). In the current era of Industry 4.0, defined by technical progress and digitalization, integrating sophisticated digital technology into traditional production processes represents a significant milestone. The Internet of Things (IoT), big data analytics, and artificial intelligence (AI) are transforming the worldwide design sector, resulting in higher production, new business models, and enhanced efficiency. This digital transition and technical development have had varying effects on numerous nations, leading to an exciting era of

technological growth. The fundamental objective of this revolution is to solve the particular issues faced by many businesses, including the fashion industry, which must undergo a considerable transformation to adapt to the shifting global industrial scene (Jin & Shin, 2021).

The global manufacturing industry is undergoing the fourth industrial revolution (Thoben et al., 2017). Like past industrial revolutions, automation has played a crucial role in this transformation (Pawar et al., 2016). Digital technologies such as artificial intelligence (AI) are transforming the whole manufacturing process in the fashion business, from design to consumer experience and trend forecasting (Pupillo, 2021). Computer-aided design (CAD) and 3D printing, two of the newest and most powerful design technologies, are essential to adopting Industry 4.0. CAD enables the construction of accurate and detailed drawings that can be adjusted as rapidly as necessary. Furthermore, 3D printing boosts productivity and hyper-personalization, enabling quick prototyping and manufacturing complicated parts (Jin & Shin, 2021). For achieving the Industrial Revolution 4.0 and sustain worldwide competitiveness in the face of quickly changing markets and increasing worldwide rivalry, the conventional garment sector must be modernized and transformed via new technologies. Thus, it is essential to identify and investigate strategic industrial upgrading options. Despite the increasing popularity of artificial intelligence (AI) as a decision-making tool, its use in the fashion and clothing sector has historically been restricted (Giri, 2021).

However, the successful application of digital transformation can change the fashion sector into a more sustainable and customer-focused enterprise (Bertola & Teunissen, 2018). Unlike past industrial revolutions, which sought to increase production and improve the quality of human life, the present revolution aims to use technology to meet difficulties in industries such as fashion. Prior studies have concentrated on individual technologies, such as robots, 3D printing, virtual and augmented reality, and AI; however, the significance of business models in determining these technologies' economic value has yet to be thoroughly investigated. This study broadly views how Industry 4.0 technology may be utilized to address significant difficulties in the global fashion sector. The research examines the current condition of the garment design business concerning Industry 4.0, focusing on the technologies that can significantly alter the supply chain, product development, and marketing tactics now employed by the industry. Thus, this article presents a detailed examination of the role of Industry 4.0 technologies in the global fashion business, providing practitioners and scholars interested in adopting Industry 4.0 in the garment sector with significant insights.

This study intends to investigate how the Industry 4.0 revolution is reshaping the global garment design industry and how firms can strategically adapt their operations to improve various aspects of their operations. It includes improving manufacturing efficiency, reducing production costs, increasing customer satisfaction, boosting sales, enhancing personnel skill sets, and enhancing overall competitiveness. By adopting effective guiding strategies that leverage the advanced technologies of Industry 4.0, apparel companies can successfully transform their conventional operations and remain competitive in a continuously expanding market.

2. Literature Review

Even though society is evolving, most garment manufacturers still utilize the conventional push supply chain model (Christopher et al., 2004; Jin & Shin, 2020; Payne & Peters, 2004). However, the inherent unpredictability of garment demand makes it impossible to accurately estimate manufacturing demand (Chang et al., 2016; Jin et al., 2023), resulting in significant price reductions and inventory buildups that reduce profitability. According to Bain & Company, the average markdown rate in the industry is around 50 percent (Sull & Turconi, 2008), which indicates that outdated business methods are ineffective. Even before the COVID-19 pandemic, several clothing manufacturers and retailers who relied on push supply chains encountered difficulties. Due to the pandemic, well-known businesses such as Nordstrom, Neiman Marcus, JC Penney, Brooks Brothers, J Crew, and Victoria's Secret filed for bankruptcy protection (Diamond et al., 2015).

According to Dart & Lewis (2017), excess is a significant issue for the conventional fashion sector. It is because output exceeds client demand. Consumer demand has decreased due to changes in the economic environment, such as an aging population and a shift in consumer tastes from product to experience (Dart & Lewis, 2017; Goryńska-Goldmann, 2017; Tomé, 2014). Even when clothing is accessible, the supply-demand imbalance may remain longer, resulting in an environmental hazard of a surplus. In a peculiar turn of events, the previous industrial revolution and global sourcing practices made mass production of inexpensive apparel conceivable. Nevertheless, the fashion industry's supply chain relies on forecasts, leading to 40–100% incorrect forecasts and 10–40% stock-outs on average, compared to 1–2% for practical products (Payne & Peters, 2004).

In the traditional fashion business, productivity meant swiftly transforming inputs like time, effort, and money into outputs (Grönroos & Ojasalo, 2004; Johnston & Jones, 2004; Vaidya et al., 2018). However, introducing Industry 4.0 has broadened the definition of productivity beyond just manufacturing more goods at a reduced price. One technique for increasing productivity is to improve the efficiency and effectiveness of production and how consumers and organizations make decisions by emphasizing precision, convenience, and speed (Anitsal & Schumann, 2007). Every fashion industry's business operations depend on productivity; thus, production and process automation are rising (Jin & Shin, 2021). To scale up hyper-personalization, it is essential to predict what customers want and improve efficiency accurately. To accomplish this, enormous quantities of data must be processed and evaluated at the group and individual levels. It is a resource-intensive endeavor until it can be performed automatically (Koehler, 2018). In the present era of Industry 4.0, customer expectations of fashion industry productivity have evolved from time, money, and effort spent shopping to convenience. Because shopping ease is the top concern for 83% of U.S. customers, businesses are investigating solutions such as size suggestion systems. Despite this, internet users anticipate better usability (A I Intelligent Automation Network, 2018).

Researchers have examined how manufacturers use robots, RFID, and industrial productivity (Bheda et al., 2003; Gurunathan et al., 2015; Michelini & Razzoli, 2004). Varukolu & Park-Poaps (2009) examined the impact of convenience on the customer purchase experience, including product search (Shim et al., 2001), payment (Lai & Liew, 2021), and multichannel experiences (Dholakia et al., 2010). Academics have recently shown interest in using Industry 4.0 technologies like augmented reality and artificial intelligence (AI) to improve how customers buy things and how productive industries are (Braglia et al., 2021). Hulland et al. (2020) even though artificial intelligence has permeated nearly every area of the fashion value chain (Luce, 2019), it has yet to be implemented on a larger scale. By 2030, AI is expected to contribute $13 trillion to global economic activity, and 70% of businesses will have incorporated at least one AI technology (Illanes et al., 2018).

2.1. The Impact of New Industry 4.0 Technologies on the Global Fashion Industry

The fashion industry is poised to undergo significant changes with the emergence of Industry 4.0. It presents opportunities for the sector to adopt eco-friendly production processes and build digital "smart networks" to engage with customers (Bertola & Teunissen, 2018). Countries like the United States and Japan are considered technological leaders, with the former experiencing a 40% increase in the use of robots in manufacturing since the onset of Industry 4.0 (Singh et al., 2021). Retail giants H&M and Zara have integrated AI-powered personalization features into their online businesses to enhance the customer experience (Anupa, 2021). Meanwhile, developing economies like India and China are gradually catching up with technological changes in the clothing business. China, in particular, has transitioned from being just a manufacturing hub to a significant player in hi-tech and innovative industries (Gatti & Richter, 2019). Chinese clothing companies like Li Ning and Anta have leveraged digital product development tools to hasten the design and development of their products (Zhu et al., 2023). However, developing countries must invest more in advanced technologies and skilled labor to remain competitive.

Although the pace of technological advancements may be uniform across countries, local textile producers must continuously invest in new technologies to stay ahead of their competitors. Clothing manufacturers in developed countries have embraced cutting-edge tools such as robotics, digital management systems, automation technologies, big data technologies, and artificial intelligence technologies to increase production output, improve quality, and remain competitive (Braglia et al., 2021; Grewal, Noble, et al., 2020). Emerging nations must develop effective upgrading programs that foster technical innovation and establish global networks to manufacture clothes.

Integrating Industry 4.0 with supply chain management poses challenges that demand new methods, concepts, and devices. According to Majeed & Rupasinghe (2017), enterprise resource planning (ERP) systems' operations could be better controlled, improved, and automated. For instance, RFID technology (Figure 1) could enhance ERP systems' efficiency in the apparel industry. RFID tags are attached to production documents and raw material bundles to gather production data. This data is utilized for inventory and production tracking. Before dispatching, PPC staff members examine production documents. Subsequently, a central database for allocation parameters is required for the decision-making toolkit. As Jin et al. (2023) stated, XML is the de facto standard for sending information from a centralized database to other enterprise-level information systems like WMS, ERP, and CRM.

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Figure 1. RFID technology

Mass customization has transformed the traditional business model to remove inefficiencies and satisfy client needs in the Industry 4.0 era (Senanayake & Little, 2010). Mass customization has been made possible in the fashion industry by allowing customers to choose sizes, washes, and patterns. Despite the efforts of companies such as Levi's, Son of a Tailor, Sumissura, and Knot Standard meeting consumer demands for precise size, fit, taste, and preference remains challenging. Large-scale and scalable technology solutions are required (Chaomei Chen & Paul, 2001).

3. Materials and Methods

This study looked at all relevant studies from the last 20 years to figure out the latest trends and most critical technological advances in the garment industry related to Industry 4.0. Robotics, intelligent manufacturing, 3D printing, 3D weaving, virtual and augmented reality, AI, big data, business models, innovation, and entrepreneurship were all used in a thorough web search. One of these included the terms "fashion," "clothing," or "apparel." The investigation utilized academic papers, conference proceedings, business pieces, and journalism as data sources. SCOPES, the journal for the fashion business, contributed a different dataset. Many ongoing projects have been found to help the traditional garment industry deal with the problems it faced during the transition to Industry 4.0. These efforts, primarily started in the last five years by technology companies working with clothing manufacturers, went along with the literature review. The analysis gives an overview of the industry's current state, points out problems with how things are done now, and says that the industry needs new ways to move forward. Alternatives to standard methodologies are put forward based on what has been found in the literature and the results of the functional project analysis. These ideas help local garment firms utilize the sophisticated technologies of Industry 4.0 to improve the personalization and innovation of their goods, use digitalization to promote a quick reaction in the supply chain, and take advantage of customization to fulfill fluctuating customer needs.

4. Results

This section examines how robots, intelligent manufacturing, 3D printing and knitting, virtual and augmented reality, and artificial intelligence are changing the fashion business. The use of these 4IR technologies is changing the traditional fashion industry, and clothing companies need to develop good ways to deal with the problems of Industry 4.0. To get around the problems caused by the traditional garment industry's move to Industry 4.0, clothing companies must use effective ways to move the industry forward. These tactics include:

4.1. Using Information Technology to Upgrade the Industrial Supply Chain

In the fashion industry, garment production consists of four essential processes: cutting, sewing, finishing, and packing, as described by Yanni (2020). However, the traditional fashion industry suffers from supply chain waste and inefficiencies. Assigning various tasks and resources within a given sequence, volume, time, and cost limit requires capabilities in advanced computer technologies and the effective utilization of big data. Therefore, the fashion sector must leverage digitization, automation, and data

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analytics, all examples of Industry 4.0 technologies that facilitate the apparel production process. Incorporating cutting-edge technology into the supply chain is an essential component of Industry 4.0. By utilizing smart manufacturing and the Internet of Things (IoT), garment manufacturers can meet customer demands for customized, flexible production at scale. Manufacturers can optimize output by using sensors to monitor manufacturing processes and reduce waste.

Utilizing a cloud-based supply chain management system is an effective method for clothing companies to automate numerous tasks, such as order tracking, inventory management, and production planning. By implementing these technologies, businesses can gain greater insight into their supply chains, minimize the risk of stock depletion, and promptly respond to customer demands. One company that has successfully implemented a cloud-based supply chain management system is Smart Wuxi, located in Wuxi, China. Their system allows easy access to a central platform that tracks inventory levels, order fulfillment, and production management. This technology has enhanced supply chain operations' speed and accuracy, reduced lead times, and increased customer satisfaction. Smart Wuxi currently partners with renowned custom brands like TMW (USA), ONLY (Japan), Greenleaf, Clothbone, and RuiXi. Their daily production objective is 1,300 units/day with an 8-day lead time (Smart Wuxi — Figure 2).

Figure 2. Smart Wuxi

SoftWear is a company based in Atlanta, Georgia, that has made an automated sewing solution based on computer vision and robotics. They claim that firms can achieve high quality and cheaper costs by applying their technologies and relocating the supply chain back to their region. The software suggests that their "Sewbot" sewing robot can construct and stitch a T-shirt in 2.5 minutes, boosting productivity per 8-hour shift and slashing labor by 90%. Moreover, one operator may oversee up to six Sewbots. In 2017, a Chinese supplier to Adidas announced cooperation with SoftWear to make 800,000 T-shirts each day for the sports brand using the Sewbot at their plant in Arkansas, consequently decreasing labor expenses to 33 cents per garment (Zhou & Yuan, 2017). Incorporating digital technology into the supply chain of the fashion sector is vital for success in the Industry 4.0 era. By adopting these new technologies and tactics, garment firms may improve the efficiency and transparency of their supply chain operations, decrease waste, and raise customer satisfaction. Overall, Industry 4.0 technologies provide a viable answer to the inefficiencies and waste in the supply chain that plague the conventional fashion sector. In conjunction with cloud-based supply chain management systems, smart manufacturing and Internet of Things (IoT) technologies can help garment firms streamline production processes, increase visibility, and respond rapidly to consumer demand.

4.2. Investing in Intelligent Software to Enhance Design Product Development

In the age of Industry 4.0, the traditional fashion industry is changing as clothing companies investigate new technologies to improve the quality of their products and make them more competitive. Big data and AI are helping companies in developed countries access technology investments and skilled labor (Goyal & Kumar, 2021). However, clothing companies in developing countries must deal with many problems, like a lack of money to invest in new technologies and a need for more skilled workers. To deal with these problems, companies in these countries must keep investing in technological innovation and use

collaborative innovation strategies to make technology development more efficient, build global networks for making clothes, and improve the quality of their products (Ng et al., 2022).

Industry 4.0 is dependent on the incorporation of new technology in product creation. Design firms can make prototypes and test ideas (VR) with the help of 3D printing and virtual reality. It reduces the time and cost required to develop a product. Powered by AI, tools may also analyze client data and preferences to create goods that better fit customers' demands. Computer-aided design (CAD) is becoming a standard tool in clothing design. It allows designers to create virtual prototypes instead of actual ones, saving time and money. CAD provides a way to reconstruct a three-dimensional human body within a computer system. It also makes surface flattening algorithms that turn a fabric piece's three-dimensional design into a two-dimensional manufacturing correlation pattern. There are methods to create designs directly on the simulated human body in 3D space, which significantly alleviates the difficulty of fitting (Wang & Tang, 2004).
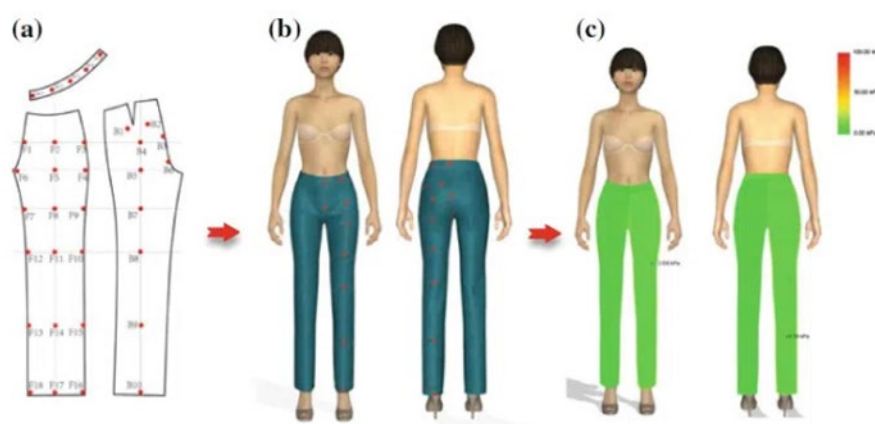

Figure 3. A robotized sewing machine

Source: Koustoumpardis & Aspragathos (2014)

Ghobakhloo (2018) talks about how Industry 4.0 technologies and their trends in manufacturing can be summed up, and he also talks about how to put them into practice. Berman (2012) says that certain technologies, like 3D printing, can change how products are designed by removing time and space limits, eliminating the need to put things together, and being cheaper. Companies like Nike, Under Armour, and Reebok have invested in these technologies to make prototypes and test products quickly and accurately. Companies like Li Ning and Anta in China have implemented digital product development systems in developing countries to speed up and improve their work (Niu, 2021). AI also lets businesses make more personalized products, improve customer service, and make supply chains more efficient. AI-powered tools can help designers develop new ideas, predict fashion trends, and customize customer products (Luce, 2019). Anomaly (Figure 4) is a custom wedding dress company that started in 2016 in San Francisco. It uses an AI-powered survey called Dress Builder to make a one-of-a-kind wedding dress by changing things like the shape, lace, neckline, and train. With four billion outfits, there are almost endless ways to customize (Nishimura, 2019).

Intelligent software has significantly revolutionized the production of clothes and other commodities. Because of these technological changes, businesses can work faster and better, leading to shorter market times, better products, and lower prices. In this case, the clothing business has become more competitive, and businesses must keep developing new ideas to stay in business (Goyal & Kumar, 2021). For the fashion industry to stay competitive in the age of Industry 4.0, it needs to use new technologies like big data, artificial intelligence, and intelligent software. Companies must invest money in new technology, work together to solve problems and make the most of new technologies. Organizations must make some alterations to remain competitive and fulfill current market expectations. The garment sector has significantly benefited from technological advancements, which have enhanced productivity, reduced expenses, satisfied customers, and increased sales.

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Figure 4. Anomalie

Lean operations, digitalization, and high energy reduce waste, lead times, and manual labor. This degree of personalization was once prohibitively expensive (Paul & Meyer, 2001). So, the fashion industry is changing to meet the needs of the digital age, which is constantly changing.

4.3. Use of High-Tech Transformation of Clothing Marketing Model

The COVID-19 epidemic has hastened the transition of the fashion business towards online buying and virtual encounters. Silvestri (2020) advances in augmented reality (AR), virtual reality (VR), and artificial intelligence (AI) technology are expected to speed up the digitalization of the sector. In their 2019 article, "Virtual Reality in the Fashion Sector," al-Haddad and Yazdanifard discuss the benefits of these technologies. Successful fashion firms of the future will be able to build new income streams by integrating product sales with services and using items to collect customer usage data (Pawar et al., 2016). Zara has made a mobile app that uses augmented reality (AR) to show people photos of fashion models wearing their products. The application can be found in many places, including the Zara website and store podiums (O'Shea et al., 2018). The sensory and practical benefits of VR and AR include time and effort savings (Colvard et al., 2018). Although current technologies are restricted in accurately displaying the fit and drape of different materials or 3D representations of the customer's body, they provide more thorough product information than typical online experiences (Cook et al., 2020). If virtual try-on technology becomes realistic enough to meet customer expectations, it may one day replace physical try-on. It would save buyers much time and make it easier to find what they want. These technologies improve the customer experience and tell businesses essential things about what customers want.

An excellent example of cutting-edge technology is the virtual fitting room company Metail, which began in 2008 in London. Metail's technology lets internet users make 3D avatars by sending pictures and body measurements. The accuracy of the avatars is between 92% and 95%. With this technology, people can try on clothes by putting them on top of their avatars and rotating them. In 2012, Tesco utilized Metail's virtual fitting room technology on its Facebook page (O'Hear, 2012). With the EcoShot add-on for Metail's VStitcher 3D fashion design software, designers can copy and recreate real-world clothes in 3D without Photoshop or collage (Jin & Shin, 2021). Gap, Inc. has tried augmented reality by releasing the Dressing Room mobile app with Avemeric, a digital 3D software company started in 2012. Consumers may use the Dressing Room app to project goods onto a personalized virtual mannequin, allowing customers to see how clothing drapes and fits without actually trying them on (O'Shea et al., 2018).

Combining virtual reality (VR) with augmented reality (AR) technologies increases efficiency, customization, and customer accessibility. Using virtual reality (VR) and other upcoming technologies can significantly enhance the shopping experience for customers to create a successful online shopping experience (Ballantine & Fortin, 2009; Dacko, 2017). Understanding how shoppers feel, the issues they

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confront, and the technology they require is crucial. Businesses utilize AI-powered chatbots and virtual personal assistants to enhance customer engagement, boost customer happiness and loyalty, expand service offerings, and encourage more people to purchase or sign up. About 60% of millennials want to talk to businesses through SMS (Benigno & Nisticò, 2020), which makes it a valuable tool for businesses to invest in and shows how vital different customer touchpoints are. In 2018, Michael Kors created Messenger, a chatbot on Facebook. It began as a shopping assistant for people interested in the new Access Sofie wristwatch collection but has now grown into a brand butler.

Figure 5. The impact of artificial intelligence on the fashion industry: Examining the effects of AI technology on consumers and fashion systems

Source: PN Evangelista (2020)

According to the company, the main goals of the chatbot were to build brand loyalty, raise brand awareness, and provide a personalized experience; to get new and existing customers interested in the brand through product discovery and inspiring stories; and to provide automated answers to frequently asked questions for a better customer service experience (The Shorty Awards, 2019). Since its inception, Michael Kors' chatbot has amassed 375,000 active users, 45,000 new users, and an impressive 98% containment rate. The management of the supply chain, the manufacturing of commodities, and the distribution of goods may be affected by new technologies. With artificial intelligence, businesses can make more informed decisions, increase supply chain management, and improve customer service. Marketing models backed by artificial intelligence are increasingly essential for apparel companies to keep up with the continuously changing fashion industry. Hence, businesses must recognize the potential of these new technologies and efficiently exploit them.

4.4. Optimize the Sharing Platform to Achieve Global Cooperation

Industry 4.0 has made it easier for companies worldwide to work together, especially in the fashion industry. By making design information portals, companies in different places can share their resources and expertise. Sharing information about product design, production schedules, and delivery dates can help businesses develop new ideas and make better decisions. The use of shared platforms simplifies cooperation with others. They keep partners up to date on production and help improve the quality and development of products so they can better serve local consumers (Demary, 2015; Tian & Jiang, 2018). Technology platforms are becoming the main driver of the sharing economy because they make it easier for businesses and their customers to talk to each other and encourage people to trade goods and services. In a study by Constantiou et al. (2016), numerous businesses have begun to use technology to bring previously unconnected individuals and their original company concepts together in the last decade. RFID, mobile devices, and portals are just some ways that technology has made materials testing management and supply chain operations more efficient and flexible (Wang, 2008; Zhang et al., 2011). Since blockchain technology emerged (Chod & Lyandres, 2021; Thomassey & Zeng, 2018), some clothing companies have started using shared platforms to make it easier for supply chain partners in different countries to talk to each other and work together.

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Industry 4.0, which involves rethinking and rebuilding economic activities to make them more sustainable, has brought circular ideas into the fashion industry. The circular economy highlights the importance of a well-functioning economy on many levels, from the national to the personal, the regional to the local, and the corporate to the individual (Geissinger et al., 2019; Saberi et al., 2019). Sustainability is essential to the fashion, on-demand service, and logistics industries' sharing economies. In order to get ready for Industry 4.0, companies that make clothes will benefit from joining global platforms and making communication plans. As "global design" becomes more critical, companies may be able to increase their sales by making the most of their different platforms. However, the clothing sector faces various challenges due to international cooperation. Some things need to be done, like regulating sharing platforms, protecting intellectual property, bridging cultural gaps, ensuring cyberspace is safe, and getting international authorities to talk to each other better (Bavykina et al., 2020; Shet & Pereira, 2021).

Despite these problems, the garment industry has much to gain from using Industry 4.0 technologies in design and production. The apparel industry can make better decisions, reduce waste, and boost innovation by sharing information on product design, manufacturing schedules, and delivery dates through collaboration platforms. By letting companies see how their products are being made in real-time, shared platforms can help them find and fix problems, improve product quality and lead times, and make it easier for them to make new, trendy products that fit the tastes of local customers.

Blockchain technology can improve the responsiveness, dependability, and information transparency of supply chain systems; integrating technologies like Radio-Frequency Identification (RFID), mobile devices, and portals can improve the efficiency and adaptability of information flow in materials testing management (Chod & Lyandres, 2021; Wang, 2008). Shah et al. (2018) H&M's centralized system connects vendors, factories, and shipping companies. It improves communication and cuts down on supply chain mistakes. The garment industry may benefit from Industry 4.0's emphasis on rethinking and rebuilding the economy's functioning at many scales and boosting the use of circular principles. However, sustainability has strong ties to several sectors, including the fashion, on-demand service, and logistics industries (Geissinger et al., 2019; Saberi et al., 2019). Suppose businesses want to help make the future of the garment industry more sustainable and fairer. In that case, they must consider how Industry 4.0 will affect their sustainability and social responsibility policies.

5. Discussion

Incorporating new technology into the garment industry as part of Industry 4.0 is promising and problematic. Businesses in the apparel industry need to innovate to survive the transformation from a product-based to a service-based business model. The increased competition brought on by the sector's digital upgrade means companies must find new and innovative ways to utilize technology. Despite their potential, technologies like the Internet of Things, artificial intelligence, and big data analytics may be challenging to implement due to a lack of knowledge, unequal access to resources, and insufficient methods for learning and mastering these tools (Robey et al., 2021). With the rise of e-commerce and social media, consumers' expectations for a consistent and personalized shopping experience across digital and physical channels have risen. The garment industry may overcome these challenges with the help of R&D and cutting-edge technologies.

However, small and medium-sized enterprises may need help due to the high cost of this technology. Junck et al. (2021) stated that privacy and security worries worsen when much information about an individual is collected and kept. Machines may replace human tasks as automation and AI gain traction, which might be a rude awakening for the labor force (Ferreira et al., 2020). Spending on research and development, employee training, and state-of-the-art technology is essential for garment companies to remain competitive and relevant in the age of Industry 4.0 (Müller et al., 2018). This strategy may help firms improve their productivity and longevity while also meeting the evolving needs of their customers. As the use of AI and automation grows, the apparel industry must prepare for a shift in the workforce by ensuring that their data is secure (Johnson et al., 2022).

6. Conclusions

In its traditional form, the apparel industry faces the challenge of adapting to Industry 4.0. However, the rewards of this transition are substantial. By effectively addressing the challenges posed by new technologies and implementing successful strategies, apparel companies can achieve substantial advancements in efficiency, quality, and competitiveness. The industry must evolve and innovate in response to changing market demands, staying ahead of the competition and remaining at the forefront of

progress. In order to tackle the challenges posed by the ongoing digitization and automation of the garment industry, traditional apparel companies must adopt effective strategies to promote the industry's development. As the garment industry moves towards "Industry 4.0," characterized by the integration of advanced technologies such as artificial intelligence, intelligent manufacturing, and human-machine collaboration, it is becoming increasingly clear that the transformation of the traditional garment industry through high-tech upgrades will be a trend that defines the future of the manufacturing sector.

Despite this, it can be noted that the current upgrade phase in the traditional garment industry is still in its conceptual stage. As the relevant policies, standards, and technologies continue to evolve and mature, developing new and innovative upgrade strategies will likely bring about a dynamic period of growth and change for the industry. The apparel industry is significantly transforming as it transitions towards Industry 4.0. This shift is driven by integrating advanced technologies such as artificial intelligence, intelligent manufacturing, and human-machine collaboration, redefining the operations of traditional apparel companies. As such, it is essential to highlight the importance of implementing effective strategies to promote the industry's development in response to the challenges posed by these new technologies. A review of the relevant academic literature indicates that developing effective strategies to address the challenges posed by digitization and automation is critical to the success of the traditional garment industry.

To remain competitive in a rapidly changing market, traditional apparel companies must embrace the potential of Industry 4.0 by developing strategies that incorporate cutting-edge technologies, personalized design, and rapid supply chain response. The integration of these technologies can lead to substantial advancements in efficiency, quality, and competitiveness, positioning apparel companies ahead of the competition and at the forefront of progress. As the industry moves towards Industry 4.0, it is becoming increasingly clear that the transformation of the industry through high-tech upgrades will be a defining trend for the future of manufacturing. However, the current upgrade phase in the traditional garment industry is still in its conceptual stage. As policies, standards, and technologies continue to evolve and mature, developing new and innovative upgrade strategies will likely bring about a dynamic period of growth and change for the industry.

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