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Innovative

Review

Innovative Technologies in Supply Chain Management for Bangladesh's Readymade Garments Sector – A Comprehensive Review

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Abstract: Ready-Made Garments (RMG) sector is crucial to Bangladesh's economy, significantly contributing to GDP, employment, and exports. However, supply chain management (SCM) inefficiencies, such as poor demand forecasting, inventory management, logistics, and quality control, pose persistent challenges. This study investigates the potential of integrating advanced technologies like AI, IoT, blockchain, Big Data Analytics, and automation to improve SCM in the Bangladeshi RMG sector. Through a review of literature, industry reports, and case studies, the study assesses the benefits and challenges of technology adoption in the sector. Advanced technologies can enhance visibility, efficiency, quality control, decision-making, and sustainability in SCM. However, challenges such as high costs, data privacy, technical complexity, and resistance to change require strategic planning to overcome. Adopting these technologies can significantly improve the RMG sector's efficiency and global competitiveness, requiring collaboration between policymakers and industry leaders. This study provides a concise analysis of technology integration in Bangladeshi RMG SCM, offering balanced insights to guide future research and industry practices.

Keywords: artificial intelligence; internet of things (IoT); blockchain; big data analytics (BDA)

1. Introduction

The ready-made garments (RMG) industry holds immense importance in Bangladesh's economy, driving significant GDP growth, employment generation, and export revenues. This sector has been pivotal in positioning Bangladesh as a major player in the global apparel market. However, the RMG industry faces challenges due to its labor-intensive nature, complex supply chains, and fluctuating market demands. In recent years, global consumer preferences have evolved rapidly, and the pace of globalization has accelerated. Traditional supply chain management (SCM) practices relying on outdated technologies and manual processes are proving inadequate to meet these modern market expectations. To address these challenges effectively, there is a critical need to enhance the resilience, flexibility, and efficiency of supply chains in the Bangladesh RMG sector through the adoption of advanced technological solutions. Implementing technologically advanced SCM solutions can improve the industry's ability to adapt to changing consumer demands and global market dynamics. This transformation is crucial for ensuring the continued growth and competitiveness of Bangladesh's RMG sector on the global stage.

Despite its economic significance, the RMG sector in Bangladesh, faces numerous supply chain challenges. According to data from the Bangladesh Garment Manufacturers and Exporters Association (BGMEA), a significant 73% of the total RMG export earnings amounting to $34.13 billion in the previous fiscal year were attributed to five primary product categories: T-shirts, sweaters, trousers, jackets, and shirts. To diversify and enter non-traditional markets, BGMEA has identified 51 high-potential products. Over the next five years, the focus will be on 31 of these items, which collectively represent a market size of $132 billion. In the fiscal year 2018-2019 alone, these products generated export revenues amounting to $7.16 billion, underscoring substantial growth prospects for the industry.

The sector faces challenges such as maintaining quality control, inaccuracies in demand forecasting, inefficiencies in inventory management, and delays in logistics and distribution. These issues are compounded by the sector's reliance on a global supply chain network involving multiple stakeholders, from raw material suppliers to end consumers. The complex and fragmented nature of

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Bangladesh's RMG supply chain makes it particularly vulnerable to disruptions, as evidenced by the impact of the COVID-19 pandemic. These disruptions underscore the urgent need for resilient supply chain management strategies capable of adapting to and mitigating such risks. Despite the potential of innovative technologies to address these challenges, their adoption within the RMG sector remains limited. Enhancing supply chain resilience and efficiency through advanced technological solutions is crucial for the sustained growth and competitiveness of Bangladesh's RMG industry on the global stage. Effectively addressing these issues requires strategic investments in modernizing supply chain practices and leveraging cutting-edge technologies to navigate the complexities and uncertainties of global markets.

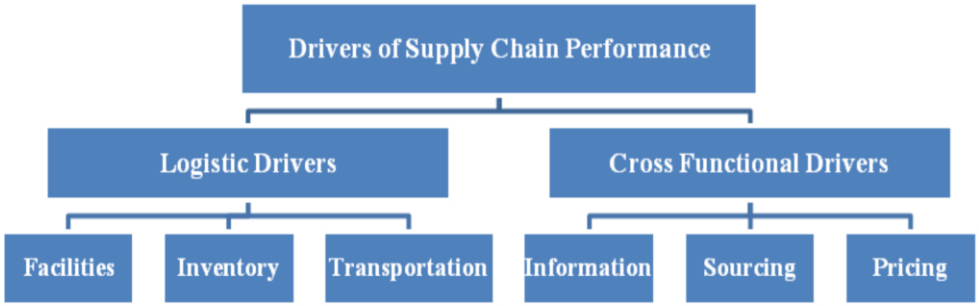

Figure 1. Drivers of Supply Chain Performance.

The estimated impact of various issues on losses in the ready-made garments (RMG) sector has been shown in figure 2. Each issue is represented along the y-axis, with its corresponding estimated impact on losses (%) indicated along the x-axis.

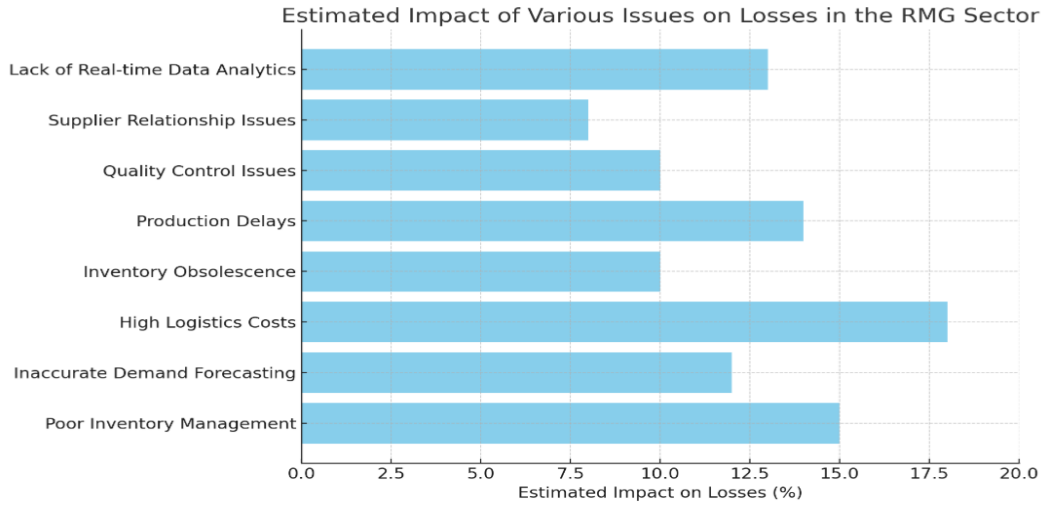

Figure 2. Estimated losses in SCM.

For a foundational understanding of the complexities inherent in managing supply chains within Bangladesh's RMG sector, highlighting the importance of addressing these challenges through strategic management and technological innovation is necessary.

Supply Chain Structure: The supply chain in Bangladesh's ready-made garments (RMG) industry is complex and layered. It starts with the sourcing of raw materials, including fibers and fabrics, from suppliers both at home and abroad. The next steps are the production of the clothing itself, including design, cutting, sewing, and finishing (Shahadat et al. 2023). After production, there are logistics and distribution channels, including storage and transport. Ultimately, goods and services flow to consumers via retail outlets, at home and abroad (Rasel, Das and Khan, 2020).

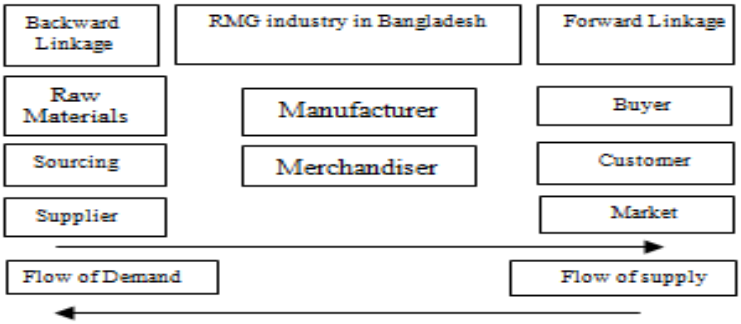

Figure 3. RMG Supply Chain.

Key Stakeholders: The RMG supply chain in Bangladesh depends on a constellation of vital actors. Suppliers are critical because they supply the raw materials needed to produce garments, and manufacturers are the ones who convert raw materials into finished garments (Khan, Islam and Habib 2023). Logistics companies handle storage and transport, keeping goods moving. Retailers pass the goods on to final consumers, and the ultimate consumers of the clothes are consumers themselves. Regulators establish standards and procedures across the industry, with quality control and compliance maintained along the supply chain (Colin 2015).

Key Challenges: Managing the supply chain in Bangladesh's RMG sector presents numerous challenges. Accurately forecasting demand remains a significant hurdle, affecting production planning and inventory management (Dash et al. 2019). Balancing supply and demand to optimize inventory levels is crucial for operational efficiency. Efficient logistics operations are essential to ensure timely deliveries and minimize transportation costs. Maintaining consistent quality across manufacturing units is another critical challenge, ensuring that products meet international standards and customer expectations. Moreover, integrating advanced technologies into operations, such as AI, IoT, and automation, poses challenges but offers opportunities for enhancing efficiency and competitiveness (Rumi et al. 2021; Tjahjono et al. 2017).

2. Innovative Technologies in RMG Supply Chain Management

Bangladesh's Readymade Garments (RMG) industry began in the 1980s and has made significant progress since then. Despite adopting new technologies, the industry is mostly at the 2.5 or 3.0 stage, while the global market is moving towards Industry 4.0 (Chowdhury and Haque 2022). Artificial intelligence and automation are revolutionizing the global garment sector by enhancing supply chain efficiency and manufacturing precision. This shift from manual processes to technology-driven production aims to reduce environmental impact and increase responsiveness. Success stories from companies like Zara and H&M underscore the crucial role of AI in optimizing inventory management and facilitating bespoke design (Ahmed et al., 2021). The Bangladesh ready-made garments (RMG) sector needs to adopt innovative technologies to address conventional supply chain management (SCM) obstacles and improve operational efficiency, responsiveness, and sustainability (Shahadat et al. 2023).

This section explores pivotal technologies such as ERP, CAD, Digital Marketing Tools, CRM, HRM, MRP, lean management, the internet of things (IoT), artificial intelligence (AI), blockchain, big data analytics (BDA), automation, robotics, and other pertinent advancements transforming SCM within the RMG industry.

1. ERP: ERP (Enterprise Resource Planning) software helps manufacturers manage various activities like order processing, sourcing, production planning, purchasing, inventory, supplier interactions, customer service, and order tracking. Typically, ERP systems use a single database to unify all company departments and functions, improving internal processes and boosting productivity (Ahsan et al. 2022).

Key benefits of ERP software

The integration of all business processes—including manufacturing, design, customer service, finance, sales, and distribution—significantly enhances workflow and productivity across the ready-made garments (RMG) industry. By effectively meeting demands for lower prices, improved quality, and faster lead times, this integration boosts confidence among business partners and consumers alike. Additionally, it provides timely and accurate information, which in turn improves productivity, decision-making, and communication within organizations (Khan & Islam, 2023). Furthermore, the automation of tasks and the reduction of duplicate work streamline operations and facilitate easy access to information, ultimately saving considerable time and resources for businesses in the sector.

Figure 4. ERP Process.

2. CAD: Technology now plays a crucial role in the fashion industry, from initial design to garment manufacturing. One significant technological advancement is the use of CAD and CAM software. While traditional pens and paper remain important, CAD allows for efficient copy-pasting, reshaping, and adding detail to sketches, enhancing creativity with colors, patterns, and shapes (Rahman et al. 2019). Computer-aided design (CAD) involves using computers to create designs, whether for vehicles or apparel. It operates in both 2D and 3D, giving designers a comprehensive view of their creations. In fashion, CAD is used for digital fashion sketches, garment design, artwork, and other design elements. Once the design process is complete, it can be transferred to computer-aided manufacturing (CAM) software, which automates and streamlines the manufacturing process (Zakir and Islam 2021).

3. CRM: Creating a great product isn't enough for a factory; they also need to manage customer relationships and boost sales. Manufacturing CRM software helps with this by organizing customer data in one place. This allows sales agents to understand customer needs, close deals faster, and find opportunities for upselling. Choosing the right CRM can be tricky due to many options. Factories should look for features like contact management, lead and sales tracking, task management, document management, reporting, inventory tracking, and sales forecasting. This software can greatly help marketing teams improve their efficiency (Chowdhury and Alam 2021).
4. Digital Marketing Tools: A digital marketing tool helps manufacturers find new buyers, target specific markets, set prices, ensure quality, and manage lead times effectively. It solves communication and presentation issues, crucial for achieving business goals like reaching more customers and increasing sales. Digital marketing such as digital ad buys, website optimization, SEO, A/B testing, email marketing, and lead scoring is vital because it's cost-effective, accessible globally, flexible for customer engagement, offers growth opportunities, showcases products through multimedia, engages interactively, tracks customers, builds authority, collaborates with influencers, and enhances brand presence (Farhana and Akter 2023).
5. MRP Material Resource Planning: MRP software is essential for managing production and inventory in the apparel industry. It helps control fabric and trim purchasing and stock levels. Specifically designed for apparel, MRP software organizes material requirements by color and quality for each finished product. This system simplifies data entry, reporting, and analysis through matrices. By accurately predicting needs, MRP software minimizes excess stock, freeing up capital. It also cuts costs associated with frequent stock-taking, making apparel manufacturing more efficient overall (Islam and Rahman 2022).

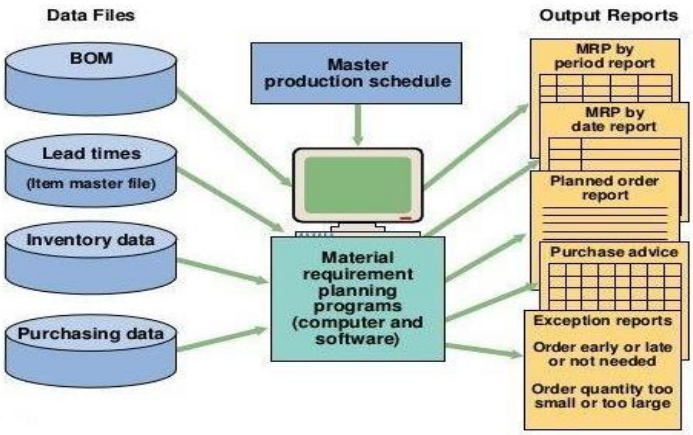

Figure 5. MRP Structure.

6. Lean Management: Lean manufacturing offers significant benefits by enhancing efficiency, reducing waste, and boosting productivity. These advantages include: i) Improved Product Quality: Efficiency gains allow for more focus on innovation and quality control, enhancing product standards. ii) Minimized Waste: Lean principles aim to maximize customer value by minimizing waste across processes, resulting in reduced lead times, rework, and inventories. iii) Enhanced Process Understanding: Implementing lean fosters a deeper understanding of processes and products, leading to improved operational knowledge (Tareq and Habib 2020).

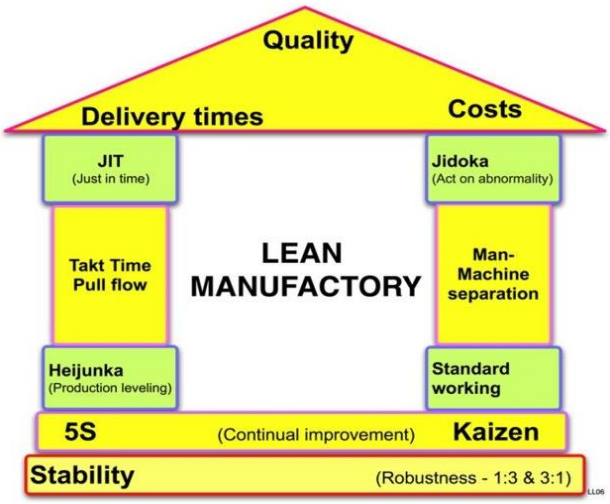

Figure 6. Lean Management.

7. Internet of Things (IoT) Applications in SCM: The Internet of Things (IoT) significantly enhances supply chain management through various applications. IoT devices, such as RFID tags and sensors, enable real-time inventory tracking, which optimizes

stock levels and minimizes losses. Additionally, IoT sensors provide real-time monitoring of goods' conditions during transit, ensuring quality control by tracking critical factors like temperature and humidity. Furthermore, these devices facilitate predictive maintenance by continuously monitoring equipment health, allowing for the prediction of maintenance needs to minimize downtime and boost production efficiency (Rumi et al., 2021). The benefits of IoT in the supply chain include enhanced visibility and transparency, improved inventory management accuracy, and reduced operational costs through efficient resource allocation.

2.1 Artificial Intelligence (AI) Applications of AI in different stages of SCM

Artificial intelligence (AI) plays a crucial role across the supply chain management (SCM) process, enhancing efficiency and mitigating risks. In the planning phase, AI improves forecasting accuracy and demand planning by examining past data to anticipate future demand trends. This aids in optimizing production and inventory decisions, minimizing waste, and enhancing resource utilization (Singh and Kumar 2021). In sourcing, AI optimizes supplier selection by analyzing supplier performance data to identify risks and opportunities, enabling informed decisions and reducing potential supply chain disruptions (Pournader et al. 2021). During manufacturing, AI enhances production planning and quality control by analyzing real-time data to pre-emptively identify quality issues. This proactive approach optimizes production processes, minimizes waste, and boosts efficiency in manufacturing operations (Duan and Zhang 2020). In the delivery phase, AI optimizes delivery routes to minimize transit times and elevate customer satisfaction (Wang et al. 2021). For returns, AI improves returns management by analyzing data to identify trends and optimize processes, minimizing waste and landfill impact. Overall, AI enhances supply chain visibility and collaboration through real-time insights and improved data sharing among partners, facilitating faster issue resolution and operational optimization (Mohsen 2023).

Application of AI in Value Creation

AI transforms supply chain management by accurately forecasting demand and optimizing operations. By analyzing historical and real-time data to predict demand, AI enables businesses to streamline sourcing, reduce transportation and warehousing costs, and minimize waste. For instance, companies like Otto and the National Grid use AI to predict supply and demand variations, considering factors such as weather and market dynamics (Gurtu and Johny 2019). AI also aids in research and development by evaluating prototypes for market success and improving design efficiency, thereby advancing smart manufacturing practices (Colin et al. 2015).

AI in Production

AI has transformed production by optimizing processes and assets, improving team collaboration between humans and robots, ensuring high quality and reliability, and preventing downtime through predictive maintenance. Robotics, a vital AI application, has advanced with technologies like object recognition, allowing robots to handle objects efficiently (Shahadat et al. 2023). For example, AI-equipped robots in warehouses navigate swiftly and deliver products based on real-time data on traffic and weather conditions. AI also improves logistics by adapting to disruptions and enhancing process reliability (Dash et al. 2019). In manufacturing, AI-driven semiconductor production reduces defects and optimizes operations. Additionally, industries like utilities benefit from AI through preventive maintenance and cost savings (Mohibullah et al. 2019).

AI in Delivery

Businesses are increasingly focusing on improving user experience through AI technologies like computer vision and machine learning. For example, in supermarkets, AI can suggest complementary products based on a shopper's preferences, enhancing convenience (Abdel-Basset et al. 2018). Athletic shoe apps use AI to recommend suitable footwear based on exercise routines, while Amazon Go stores allow checkout-free shopping through AI-driven computer vision. AI-powered drone deliveries by companies like Amazon and UPS are also streamlining logistics across various sectors (Nipa 2020).

AI in Smart Retailing

AI revolutionizes retail and manufacturing by enabling smarter decisions through accurate real-time forecasting, improved supply management, and impactful promotional strategies. It optimizes assortment and pricing while enhancing operational efficiency through robotics and process optimization, reducing manual labor costs (Varma & Khan, 2014). Interactive robots powered by advanced computer vision recognize and categorize objects, enabling safe interaction in various contexts. Companies like Swisslog and DHL efficiently utilize these technologies (Phasinam et al. 2022).

2.2 Blockchain in SCM

Blockchain technology ensures transparency and traceability within supply chain management by maintaining an immutable ledger that tracks goods from raw materials to finished products. This feature enhances trust among stakeholders and verifies the authenticity of materials, which is crucial for ethical sourcing practices (Pournader et al. 2021). Furthermore, smart contracts powered by blockchain automate and enforce agreements, ensuring seamless transactions, prompt payments, and reliable deliveries while minimizing disputes (Duan and Zhang 2020). This innovation significantly strengthens accountability and operational efficiency in supply chain management. The key benefits of implementing blockchain technology in SCM include increased transparency and trust, enhanced traceability and accountability, and reduced risks of fraud and counterfeiting (Gurtu and Johny 2019).

2.3 Big Data Analytics in SCM

Big data analytics plays a pivotal role in enhancing supply chain management by providing valuable consumer insights and optimizing logistics operations (Singh and Kumar 2021). By analyzing vast amounts of data, businesses can better understand consumer behavior and preferences, enabling personalized marketing and product development (Sarı 2021). Additionally, logistics optimization is achieved through the analysis of large datasets related to transportation routes, traffic patterns, and delivery times, leading to reduced operational costs (Liu and Zeng 2019). Big data analytics also enables companies to assess supplier performance, identify potential risks, and enhance collaboration with suppliers (Dash et al. 2019). The benefits of incorporating big data analytics into SCM include

enhanced decision-making supported by data-driven insights, improved efficiency and cost savings in logistics and inventory management, and a better understanding of consumer behavior and market trends (Mohsen 2023).

2.4 Automation and Robotics in SCM

The integration of automation and robotics in supply chain management has significantly transformed manufacturing and logistics processes (Tjahjono et al. 2017). In manufacturing, automated machines and robotics streamline various tasks such as garment cutting, sewing, and finishing, which enhances production speed and consistency (Mohibullah et al. 2019). Warehouse automation employs robotics and automated systems to efficiently handle inventory storage, retrieval, and packaging, leading to reduced labor costs and errors (Parkhe and Thakar 2022). Moreover, innovations such as drones and autonomous vehicles are being explored for efficient last-mile delivery, which improves delivery speed and effectiveness (Phasinam et al. 2022). The primary benefits of automation and robotics in SCM include increased production efficiency and consistency, reduced labor costs and human error, and faster, more efficient logistics and delivery operations (Khan et al. 2023).

2.5 Information Technology in Supply Chain

Information and communication technology (ICT) is crucial across various organizational domains, significantly enhancing data storage, processing, and exchange within enterprises and throughout supply chains (Varma and Khan 2014). In manufacturing, ICT is instrumental in developing software that streamlines shop-floor operations while fostering connectivity between businesses, consumers, and suppliers (Colin et al. 2015). The impact of ICT has grown substantially over time, contributing to efficient business operations and shaping future production processes (Nipa 2020).

2.6 RFID in SCM

Radio-Frequency Identification (RFID) technology enhances supply chain efficiency by enabling precise identification of items and delivering real-time data (Sarac et al. 2010). By combining RFID with barcode technologies, logistics operations can be accelerated, waste can be reduced, and cost savings can be generated throughout the supply chain (Dash et al. 2019). In the apparel industry, where manual management of work-related information is common, implementing RFID on the factory floor provides real-time insights into operational bottlenecks and production line statuses (Rasel et al., 2020). This technology improves overall productivity and efficiency, helping manufacturers meet delivery deadlines by closely monitoring factory activities (Khan et al. 2023).

2.7 Big Data in Manufacturing

Big Data Analytics (BDA) has transformed the manufacturing sector by leveraging large amounts of data to improve productivity through timely information delivery (Shahadat et al. 2023). Since the advent of computers, the manufacturing industry has increasingly relied on data and technology to streamline processes related to product design, production, and delivery (Duan & Zhang, 2020). Today, the sector generates vast amounts of data from electronic devices, sensors, and digital machinery, including RFID technology on shop floors and production lines (Naskar et al., 2020). BDA facilitates better logistics, quality control, supply planning, and defect monitoring, ultimately enhancing overall efficiency and productivity in manufacturing (Sarı 2021).

This review aims to explore the impact of innovative technologies on supply chain management (SCM) in Bangladesh's RMG industry and mitigate the losses. It analyzes the integration of technologies like AI, IoT, blockchain, big data analytics, automation, and robotics in SCM practices. The review highlights the benefits, applications, and challenges of adopting these technologies, emphasizing their potential to enhance SCM efficiency. Additionally, it offers recommendations for future research and practical implementation to address unique challenges in Bangladesh's RMG sector, such as supply chain complexity, quality control, and global market dynamics.

3. Methods

A systematic approach was used for selecting and analyzing literature relevant to technology integration in Bangladesh's RMG sector. Industry reports, academic studies from databases like JSTOR, IEEE Xplore, and Scopus, and additional theses and conference proceedings were studied. The search focused on SCM and innovative technologies like AI, IoT, blockchain, and automation, using publications from 2014-2024 and limiting to English for accessibility. Criteria included peer-reviewed articles and industry reports on technology's impact in RMG SCM, excluding unrelated or outdated studies. Data extraction involved gathering bibliographic details, study focus, and findings, with thematic and comparative analysis identifying trends and insights.

3.1 Discussion

The advent of new technology in supply chain management (SCM) is already changing the game, and it is doing so in dramatic fashion - could lead to unprecedented benefits and the solution to problems for Bangladesh's ready-made garments (RMG) sector.

3.2 Benefits of Technology Integration

Integration of advanced technologies in supply chain management significantly enhances visibility and transparency, allowing businesses to track goods in real time using the internet of things (IoT) and blockchain. This capability enables stakeholders to know a transparent record of transactions, ensuring that the origins and processes of goods are permanently documented on an immutable ledger. This heightened visibility not only fosters trust among stakeholders but also aids in the identification and resolution of issues more swiftly. Automation and robotics streamline the manufacturing and transportation processes, reducing human error while improving production speed and lowering labor costs. Incorporation of AI and big data analytics optimizes inventory management through more accurate demand forecasting, which helps prevent both surplus stock and stock shortages, leading to overall cost reductions.

Advanced technologies enhance quality control and better decision-making in the RMG sector. Automated inspections powered by AI can identify production faults early in the process, ensuring that product quality is maintained and minimizing waste. Condition monitoring through IoT sensors during transit helps preserve product integrity and reduce spoilage. Big data analytics provide actionable insights that support more informed decisions regarding production, supply, and distribution strategies. Digital twin technology facilitates scenario planning by allowing businesses to simulate various conditions, optimizing supply chains and increasing resilience in the face of disruptions. This technological empowerment increases agility and responsiveness, enabling companies to swiftly adapt

to market and consumer changes. Traceability features enabled by blockchain and IoT foster ethical and sustainable sourcing practices while allowing data analytics to promote resource efficiency, ultimately contributing to a more sustainable and environmentally friendly supply chain.

Table 1. Benefits of various technologies in the ready-made garments (RMG) supply chain.

Technology	Statistical Data	Benefit Description
Blockchain	90 % reduction in disputes	Enhances trust and accountability among stakeholders
Big Data Analytics	8-10% increase in sales	Enables personalized marketing and product development
Automation and Robotics	20-25% increase in production efficiency	Streamline Processes, increasing speed and consistency
Information Technology	30 % reduction in operational cost	Improve data management and operational efficiency
RFID Technology	20 % decrease in inventory cost	Provide real time data for better inventory management
Artificial intelligence	15 % improvement in demand forecasting accuracy	Optimizes resource allocation and reduce waste.

3.3 Challenges of Technology Integration

Ready-made garments (RMG) sector in Bangladesh holds tremendous potential for leveraging advanced technologies in supply chain management (SCM). However, this potential can only be fully realized by addressing significant barriers, including high initial investment costs, data security risks, and technical complexities. The financial burden associated with implementing technologies such as artificial intelligence (AI), internet of things (IoT), and robotics is considerable. This includes not only the costs of acquiring hardware like computers, sensors, and robots, but also the software expenses related to algorithms, platforms, and security measures. Integrating these new technologies with existing systems requires specialized labor and expertise, adding to the overall implementation costs.

Data privacy and security concerns pose substantial challenges. The proliferation of IoT devices and big data analytics necessitates the handling of sensitive personal information, leading to significant privacy risks. Increased connectivity results in more entry points for potential cybersecurity attacks, making robust data protection essential. The complexity of advanced technologies demands a highly skilled workforce proficient in AI, data analysis, and cybersecurity, which requires substantial investment in training programs. Resistance to change within organizations can further hinder technological adoption, as cultural factors may lead to employee pushback against new systems. Coupled with regulatory and compliance challenges that vary by location, these factors create a complex landscape for the RMG sector. Sustainability concerns also emerge, as technologies such as blockchain and AI have significant energy consumption and contribute to e-waste, necessitating sustainable management and recycling solutions to address their environmental impact.

3.4 Trends in Supply Chain Management for Bangladesh's RMG Sector

Emerging technologies and innovative practices are reshaping the future of supply chain management (SCM) within Bangladesh's ready-made garments (RMG) industry, driving innovation and efficiency while enhancing competitiveness and sustainability. Advanced artificial intelligence (AI) and machine learning applications enable precise demand forecasting and inventory management through deep learning algorithms that analyze data and market patterns. Autonomous decision-making capabilities of AI will optimize routing and logistics in real time, ensuring that goods take the most efficient path through the supply chain. Additionally, the integration of 5G technology will improve connectivity between Internet of Things (IoT) devices, allowing for better monitoring and control of supply chain operations. This will facilitate the development of unmanned, intelligent factories that can respond more quickly and agilely to changing production needs.

The expanded use of blockchain technology can revolutionize traceability in the RMG supply chain, ensuring the authenticity of materials and promoting ethical sourcing practices. Decentralized networks enabled by blockchain will facilitate direct transactions and enhance information sharing among stakeholders, thereby increasing transparency and collaboration across the supply chain. The focus on sustainable and circular supply chains will prioritize practices such as reuse, recycling, and repurposing, significantly reducing waste and environmental impact. Advanced technologies will also support accurate sustainability reporting, allowing companies to track the environmental costs of their operations. Moreover, virtual prototyping through augmented reality (AR) and virtual reality (VR) will minimize the need for physical samples in product development while enhancing customer experiences with immersive technologies like virtual fitting rooms. Lastly, the adoption of advanced robotics, particularly collaborative robots (cobots), will improve efficiency and safety on the manufacturing floor, enabling humans and machines to work together seamlessly, while automated quality control systems will uphold high production standards by minimizing human error.

3.5 Research Gaps in Technology Integration for Supply Chain Management

While the ready-made garments (RMG) industry is vital to Bangladesh's economy, there are significant gaps in the literature regarding the integration of advanced technologies into its supply chain management (SCM). Despite the promise of artificial

intelligence (AI) and machine learning in enhancing demand forecasting and operational efficiency, empirical evidence on their adoption within the RMG sector is scarce, leaving questions about their effectiveness and reasons for limited application. While blockchain technology offers potential for improved supply chain visibility and traceability, there has been minimal exploration of its implementation in Bangladesh, highlighting the need for pilot studies to assess feasibility and benefits.

The future of sustainable, circular supply chains in the RMG industry remains uncertain due to a lack of understanding of current practices and the necessity for practical models. Transformative potential of augmented reality (AR) and virtual reality (VR) in design and customer experience has not been adequately investigated in the context of Bangladesh. Robotics and automation could significantly enhance productivity and quality control, but research on their application, economic implications, and impact on the labor force is limited. Lastly, effective integration of technology relies on workforce development, yet little is known about the technical skills gaps and necessary training programs within the RMG industry.

4. Conclusions

Integration of advanced technologies into supply chain management (SCM) is essential for the continued growth and competitiveness of Bangladesh's ready-made garments (RMG) sector. This study has explored the significant benefits that technologies such as AI, IoT, blockchain, and automation can bring to the RMG industry, including enhanced visibility, improved efficiency, better quality control, data-driven decision-making, increased agility, and sustainability. These technologies are pivotal in addressing the sector's key challenges, including demand forecasting accuracy, inventory management, and efficient logistics. However, the adoption of these technologies also presents several challenges. High initial investment costs, data privacy concerns, technical complexities, and resistance to change are significant hurdles that need to be addressed. Ensuring interoperability and adherence to regulatory standards remains crucial for the successful implementation of these technologies. Despite these challenges, the potential benefits of technology integration in SCM for Bangladesh's RMG sector are substantial. By strategically managing the obstacles and leveraging the capabilities of these advanced technologies, the sector can achieve significant improvements in operational efficiency and sustainability. Future research should focus on developing frameworks for overcoming these challenges and maximizing the benefits of technology integration, thereby supporting the evolution of a more resilient, responsive, and sustainable RMG supply chain in Bangladesh.

References

Afanasyev, Valentine Y, Lyubimova Natalia G, Ukolov Vladimir F, Shayakhmetov Salavat R. 2019. Digitalization of energy manufacture: Infrastructure, supply chain strategy and communication. *International Journal of Supply Chain Management* 8: 601-609. https://doi.org/10.59160/ijscm.v8i4.3544

Abdel-Basset, Mohamed, Manogaran Gunasekaran, Mohamed M. 2018. Internet of Things (IoT) and its impact on supply chain: A framework for building smart, secure, and efficient systems. *Future Generation Computer Systems* 86: 614-628. https://doi.org/10.1016/j.future.2018.04.051

Bala, Shukti, Rumi Maruf Hasan, Shah A M.M. Mubassher, Sayem Md Abu, Abedin, Md Minhajul. 2021. Future tradeoff under fourth industrial revolution in Bangladesh: a study on RMG sector. *International Journal of Social, Political and Economic Research* 8: 198-215. https://doi.org/10.46291/IJOSPERvol8iss1pp198-215

Colin, Monica, Galindo Raquel, Hernández Octavio. 2015. Information and communication technology as a key strategy for efficient supply chain management in manufacturing SMEs. *Procedia Computer Science* 55: 833-842. https://doi.org/10.1016/j.procs.2015.07.152

Dash, Rupa, McMurtrey Mark, Rebman Carl, Kar Upendra K. 2019. Application of artificial intelligence in automation of supply chain management. *Journal of Strategic Innovation and Sustainability* 14. https://doi.org/10.33423/jsis.v14i3.2105

De Barros, Alexandre Pinheiro, Ishikiriyama Celia Satiko, Peres Rafael Cordeiro, Gomes Carlos Francisco Simoes. 2015. Processes and benefits of the application of information technology in supply chain management: An analysis of the literature. *Procedia Computer Science*, 55: 698-705. https://doi.org/10.1016/j.procs.2015.07.077

Gurtu, Amulya, Johny Jestin. 2019. Potential of blockchain technology in supply chain management: A literature review. *International Journal of Physical Distribution & Logistics Management* 49: 881-900 http://dx.doi.org/10.1108/IJPDLM-11-2018-0371

Habib, Md Mamun, Sabah Seeratus, Chowdhury Farzana, Raisa Rodoshi, Shuvo Tamim Forhad. 2024. Technology Enabled Ready-Made Garments Supply Chain Management: a Literature Review. *Revista de Gestão Social e Ambiental* 18: e08842-e08842. DOI: https://doi.org/10.24857/rgsa.v18n10-188

Jagtap, Santosh T, Thakar Chetan M, Imrani Quail El, Phasinam Khongdet, Garg Shaifali, Ventayed Randy Joy Mango. 2021. A framework for secure healthcare system using blockchain and smart contracts. In 2021 Second International Conference on Electronics and Sustainable Communication Systems (ICESC) (pp. 922-926). Coimbatore, India. http://dx.doi.org/10.1109/ICESC51422.2021.9532644

Khan, Ziarat H, Islam Gazi Md. Nurul, Habib Mamun Md. 2023. Technology-driven supply chain management in readymade garments: A literature review. *International Supply Chain Technology Journal* 5: 9. http://dx.doi.org/10.20545/isctj.v09.i05.01

Mohibullah, A. T. M, Takebira Umme Magreba, Mahir Shadman Qamar, Sultana Ajmery, Rana Masud, Hossain A. K. M. Sajjad. 2019. High-tech machine in RMG industry: Reducing SMV, lead time and boosting up the productivity. *Journal of Textile Engineering & Fashion Technology* 5: 29-34. DOI:10.15406/jteft.2019.05.0017

Mohsen, Baha M. 2023. Developments of digital technologies related to supply chain management. *Procedia Computer Science* 220: 788-795. https://doi.org/10.1016/j.procs.2023.03.105

Naskar, Suvendu, Basu Preetam, Sen A K. 2020. *A literature review of the emerging field of IoT using RFID and its applications in supply chain management*. In: *Securing the Internet of Things: Concepts, Methodologies, Tools, and Applications.* https://doi.org/10.4018/978-1-5225-2104-4.CH001

Nipa, Nymatul Jannat. 2020. Validating existing ICT infrastructure of RMG sector: A study on Bangladesh. *International Journal of Industrial and Manufacturing Systems Engineering* 5: 28-38. doi: 10.11648/j.ijimse.20200503.11

Parkhe, Shailesh S, Thakar Chetan. M, Kulkarni Vaibhav V, Mishra Hari Govind. 2022. Implementation of IoT in production and manufacturing: An industry 4.0 approach. *Materials Today: Proceedings* 51: 2427-2430. https://doi.org/10.1016/j.matpr.2021.11.604

Patterson, Kirk A, Grimm Curtis M, Corsi Thomas M. 2003. Adopting new technologies for supply chain management. *Transportation Research Part E: Logistics and Transportation Review* 39: 95-121 https://doi.org/10.1016/S1366-5545(02)00041-8

Phasinam, Khongdet, Kassanuk Tassanuk, Shinde Priyanka P, Thakar Chetan M. 2022. Application of IoT and cloud computing in automation of agriculture irrigation. *Journal of Food Quality* 2022, Article ID 8285969. https://doi.org/10.1155/2022/8285969

Pournader, Mehrodokht, Ghaderi Hadi, Hassanzadegan Amir, Fahimnia Behanam. 2021. Artificial intelligence applications in supply chain management. *International Journal of Production Economics* 241: 108250. https://doi.org/10.1016/j.ijpe.2021.108250

Rasel, Md Shamsuzzaman, Das Dip, Khan Malaz Rahman. 2020. Current scenario of textile sector in Bangladesh (2019): A comprehensive review. *International Journal of Innovative Studies in Sciences and Engineering Technology* 6:52-55.

Sarac, Aysegul, Absi Nabil, Dauzère-Pérès Stephane. 2010. A literature review on the impact of RFID technologies on supply chain management. *International Journal of Production Economics* 128: 77-95. https://doi.org/10.1016/j.ijpe.2010.07.039

Sarı, Ahmet. 2021. A review of artificial intelligence applications in supply chain management. *Business and Economics Research Journal* 12: 759-776.

Shahadat, M M Hussain, Chowdhury Abu Hena Mohammed Yaseen, Nathan Robert Jeyakumar, Fekete-Farkas Maria. 2023. Digital technologies for firms' competitive advantage and improved supply chain performance. *Journal of Risk and Financial Management* 16: 94. https://doi.org/10.3390/jrfm16020094

Shinde, Priyanka P, Oza, Kavita S, Kamat, R K, Thakar Chetan M. 2022. Big data analytics for mask prominence in COVID pandemic. *Materials Today: Proceedings* 51: 2471-2475. https://doi.org/10.1016/j.matpr.2021.11.620

Singh, Suraj K, Kumar Pardeep. 2021. A systematic review of artificial intelligence in supply chain management: Recent trends and future directions. *International Journal of Production Research* 59: 554-577.

Tjahjono, Bill, Esplugues Carlos, Ares Enrique, Pelaez Gabriel. 2017. What does industry 4.0 mean to supply chain? *Procedia Manufacturing* 13: 1175-1182. https://doi.org/10.1016/j.promfg.2017.09.191

Varma, Dr. TN, Khan D. A. 2014. Information technology in supply chain management. *Journal of Supply Chain Management Systems* 3. https://ssrn.com/abstract=2921128