

Investigating the Technological Impact on RMG Supply Chain: A Post-Pandemic Scenario

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Abstract

This study investigates the technological transformation of Bangladesh's Ready-Made Garment (RMG) supply chain in the aftermath of the COVID-19 pandemic, with a focus on operational efficiency, supply chain resilience, and environmental sustainability. Utilizing a mixed-methods approach, the research draws on primary data from 249 experienced RMG professionals and secondary sources, including industry reports and academic literature. The analysis is structured around the Technology–Organization–Environment (TOE) framework, which elucidates how internal capabilities, technological readiness, and external pressures collectively shape digital adoption. Findings reveal that technologies such as Enterprise Resource Planning (ERP), Artificial Intelligence (AI), the Internet of Things (IoT), and Blockchain are increasingly integrated into supply chain processes, enhancing lead time efficiency, defect detection, traceability, and compliance. However, implementation is constrained by capital intensity, skill shortages, infrastructural limitations, and interoperability issues. Despite these challenges, external forces, including buyer mandates, regulatory shifts, and government support, are accelerating the sector's digital evolution. This study contributes to the emerging literature on technology-driven supply chain management in developing economies and offers actionable insights for policymakers, global buyers, and industry leaders seeking to foster a resilient, ethical, and future-ready RMG ecosystem.

Keywords

RMG Supply Chain, Digital Transformation, ERP, AI, Blockchain, IoT, Sustainability, TOE Framework, Post-Pandemic Resilience

1. Introduction

The COVID-19 pandemic has profoundly disrupted global industries, exposing the vulnerabilities of traditional supply chain systems. Bangladesh's Ready-Made

Garments (RMG) sector, constituting the backbone of its national economy, experienced unprecedented setbacks due to large-scale order cancellations, temporary factory shutdowns, labor shortages, and logistics breakdowns. These disruptions underscored the fragility of existing supply chain structures and catalyzed an urgent reevaluation of operational strategies, prompting stakeholders to explore digital transformation as a pathway to resilience, sustainability, and efficiency.

This study investigates the technological evolution of the RMG supply chain in the post-pandemic context, with a specific focus on the adoption of emerging technologies such as Enterprise Resource Planning (ERP), Artificial Intelligence (AI), Blockchain, and the Internet of Things (IoT). The primary objective is to assess how these technologies influence operational efficiency, foster sustainability, and contribute to long-term resilience within the sector. The research employs a mixed-methods approach, integrating primary data collected from 249 industry professionals each possessing a minimum of five years of experience in the RMG field with secondary data derived from scholarly literature, industry reports, and policy documents.

To structure this investigation, the paper is organized into several sections. Following this introduction, the literature review synthesizes existing scholarship on supply chain management, digital transformation, and pandemic-induced disruptions within the RMG industry. The methodology section outlines the data collection and analysis procedures, ensuring transparency and replicability. The theoretical and conceptual frameworks provide a foundation for interpreting the impact of technological interventions on supply chain performance. Subsequent sections present empirical findings, analyze the implications of digital adoption, and explore emerging trends, challenges, and policy considerations. The conclusion offers a synthesis of key insights, acknowledges study limitations, and suggests avenues for future research.

While the survey sample is robust in terms of participant expertise and sectoral relevance, it is important to acknowledge its limitations. The data may not comprehensively capture the perspectives of micro, small, and regionally dispersed enterprises, particularly those operating outside major industrial zones or within niche segments of the RMG supply chain. This constraint should be considered when generalizing the findings, and it underscores the need for broader, more inclusive studies in subsequent research.

Ultimately, this paper contributes to the growing body of knowledge on technology-driven supply chain transformation by highlighting the RMG sector's digital trajectory in a post-pandemic world. It offers critical insights for academics, policymakers, and practitioners aiming to foster sustainable, adaptive, and future-ready industrial ecosystems.

2. Literature Review

2.1. Supply Chain Management in the RMG Sector

Supply Chain Management (SCM) focuses on ensuring customer satisfaction,

particularly in relation to manufacturing and services, which are essential aspects of the Bangladesh Garment Industry. It addresses all customer needs, with a primary focus on fulfilling the expectations of buyers within the industry. SCM involves managing a network of interconnected businesses, from suppliers to manufacturers and buyers, to deliver goods and services, such as lead time and shipment, required by end customers in the supply chain (Tanvir & Muqaddim, 2013). Additionally, it encompasses sourcing raw materials, trims, accessories, work-in-progress inventory, and finished products, overseeing their movement from the point of origin to final consumption within the garment industry.

A supply chain comprises several key factions, including raw material suppliers, manufacturers, distributors, customers, and consumers. Additionally, other stakeholders such as customs authorities, the Export Promotion Bureau (EPB), ports, transportation services, and clearing and forwarding (C&F) agents play a crucial role in facilitating supply chain operations. An effective supply chain requires seamless coordination among these entities to ensure efficiency and reliability in the movement of goods and services (Arnob et al., 2020). In the context of the Bangladesh Garment Industry, the supply chain operates as a structured progression in which raw materials, including accessories, are transferred from suppliers to garment manufacturers in exchange for orders and payments (see Figure 1).

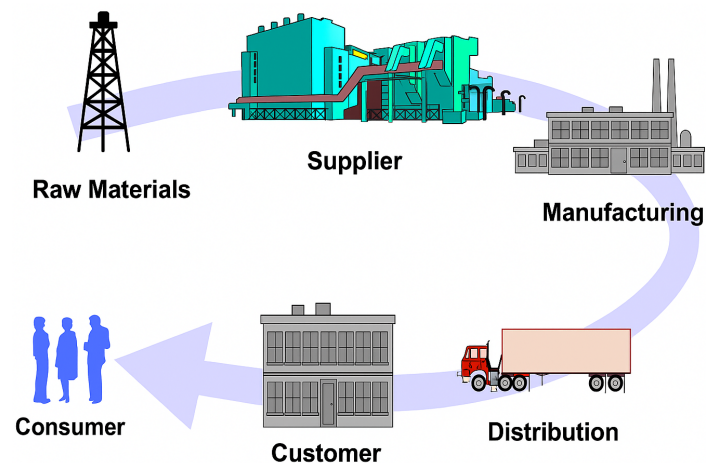


Figure 1. SCM work view in Bangladesh Garment Industry.

The fundamental components of this supply chain process include suppliers, garment industries, individuals involved in production and logistics, raw materials, finished goods, and the financial transactions necessary to sustain operations (Tanvir & Muqaddim, 2013; see Figure 2).

2.2. Technological Advancement in RMG Supply Chain Management

The integration of digital technologies in the Ready-Made Garment (RMG) sector has emerged as a strategic necessity in response to increasing buyer expectations, volatile global demand, and post-pandemic supply chain disruptions. Advanced

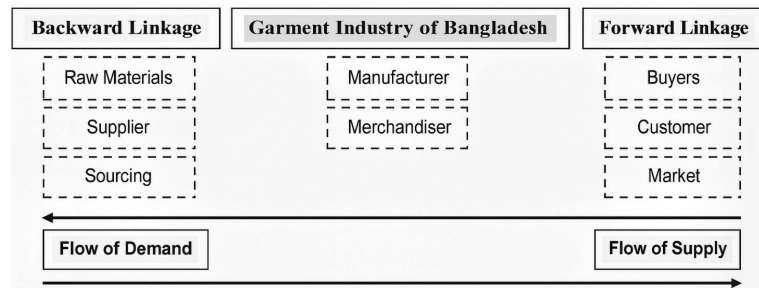


Figure 2. Basic diagram for supply chain in the garment industry.

technologies, particularly Enterprise Resource Planning (ERP), Artificial Intelligence (AI), Blockchain, and the Internet of Things (IoT), are reshaping how supply chains are designed, operated, and managed. These tools provide the infrastructure for improved visibility, real-time responsiveness, and long-term competitiveness (Ahmed et al., 2021). The following sections provide an in-depth analysis of each technology's functional application and sector-specific impact.

2.2.1. Enterprise Resource Planning (ERP)

ERP systems are comprehensive software solutions that integrate core supply chain functions procurement, inventory, finance, production planning, and order management, into a centralized digital platform. In the Bangladeshi RMG context, ERP is increasingly utilized to streamline the procurement of raw materials, automate bill of materials (BOM) management, and synchronize production schedules with shipment deadlines. By aggregating real-time data from different departments, ERP reduces administrative redundancies and enhances decision-making accuracy (Khan et al., 2023).

Manufacturers employing ERP systems report a marked reduction in cycle time due to improved resource planning and automated order processing. For instance, ERP tools enable demand-driven procurement by aligning fabric sourcing with buyer forecasts, minimizing overstock and obsolescence. Quality control is also enhanced, as ERP integrates with production line data to track defects, maintain compliance records, and facilitate corrective actions. These systems support compliance with international standards (e.g., ISO, WRAP, BSCI) by maintaining digital audit trails and documentation that are easily retrievable for buyer verification.

2.2.2. Artificial Intelligence (AI)

AI technologies bring adaptive intelligence to the supply chain, enabling predictive modeling, dynamic scheduling, and enhanced decision-making. In the RMG sector, AI-based algorithms are leveraged for demand forecasting, analyzing historical sales data, seasonal demand fluctuations, and market signals to project future order volumes. This predictive capability is critical for optimizing procurement lead times, raw material inventory levels, and production capacity allocation (Baryannis et al., 2019).

AI also plays a significant role in quality control through the deployment of

computer vision systems. These systems automate defect detection in fabrics, embroidery, stitching, or packaging, significantly reducing reliance on manual inspection and lowering rejection rates. Additionally, AI-driven process optimization tools help in balancing production lines by dynamically adjusting workloads based on operator performance and real-time order statuses.

During the COVID-19 pandemic, AI-supported scenario planning tools enabled manufacturers to rapidly simulate and evaluate different sourcing and production strategies under varying constraints, aiding business continuity. Beyond operations, AI is also applied in supplier evaluation and risk profiling, helping firms select resilient sourcing partners (Ivanov, 2021).

2.2.3. Blockchain Technology

Blockchain, a decentralized and tamper-resistant digital ledger, provides transformative capabilities for enhancing traceability, transparency, and trust in complex supply networks. In the RMG sector, where global buyers are increasingly concerned with ethical sourcing and labor standards, blockchain ensures end-to-end visibility of product provenance.

Practical applications include the digital verification of raw material origins (e.g., organic cotton), tracking environmental compliance (e.g., dyeing process certifications), and validating fair labor practices across supplier tiers. Each transaction or process stage fiber sourcing, spinning, dyeing, cutting, sewing, packaging, and shipping is recorded on the blockchain, providing an immutable chain of custody that stakeholders can access in real time (Nipa, 2020).

Blockchain smart contracts are also being piloted to automate payment terms based on delivery milestones, thereby reducing the risk of payment disputes and improving cash flow predictability. This is particularly important for small- and mid-tier suppliers that often face delayed payments from large buyers. In the long term, blockchain adoption can serve as a strategic differentiator in building buyer confidence and ensuring supply chain integrity.

2.2.4. Internet of Things (IoT)

IoT technologies involve the interconnection of machines, devices, and systems through sensors and data communication networks. In garment manufacturing plants, IoT is used for real-time monitoring of machine status, temperature, humidity, and energy usage parameters that significantly affect fabric quality and operational efficiency.

IoT applications include predictive maintenance systems, which analyze machinery health indicators (vibration, thermal patterns, runtime) to preempt equipment failures and reduce downtime. In warehousing and logistics, IoT-enabled RFID tags facilitate automated inventory tracking, reducing human error and enabling just-in-time (JIT) delivery models. Real-time geolocation of shipments via GPS-integrated sensors allows logistics teams to monitor delays and adjust distribution plans dynamically.

Environmental benefits are also notable: IoT-based monitoring systems opti-

mize resource consumption, enabling compliance with sustainability certifications (e.g., Higg Index, LEED). Waterless dyeing units and energy-efficient production lines are increasingly governed by IoT feedback loops, ensuring operational parameters remain within sustainable thresholds. (See **Figure 3**)

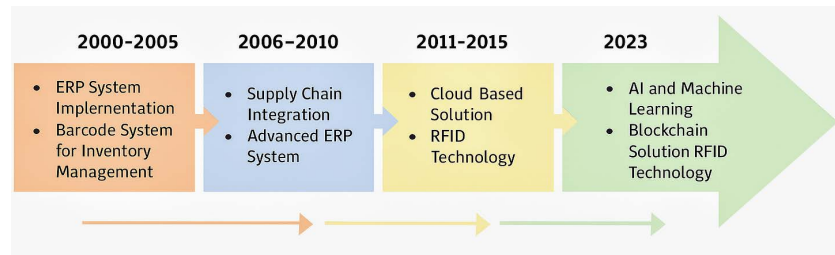


Figure 3. Technological advancement in RMG supply chain.

2.3. Impact of Pandemic on RMG Supply Chain Management

The outbreak of the pandemic in December 2019 caused significant disruptions to the global economy, severely affecting production, supply chains, and manufacturing activities. As one of the largest contributors to Bangladesh's economy, the Ready-Made Garment (RMG) industry, which provides approximately USD 5 billion in wages to its workforce, faced unprecedented challenges due to the pandemic (BGMEA, 2020). These wages circulate within the economy approximately 2.5 times, amplifying the economic impact of the sector. However, the crisis led to substantial financial distress, particularly following the large-scale cancellation and suspension of export orders. By March 2020, approximately 1150 factories reported order cancellations and suspensions from international buyers, amounting to a loss of USD 3.18 billion (BGMEA, 2020). These cancellations resulted in severe financial strain on manufacturers, leading to difficulties in meeting bank liabilities, covering overhead expenses, and paying wages. In extreme cases, these financial pressures resulted in bankruptcy and the permanent closure of factories. The crisis also exposed the limitations of industry partnerships and cooperation, as many businesses struggled to navigate the economic downturn (BGMEA, 2020).

The decline in demand further exacerbated financial challenges for the RMG sector. Between January and September 2020, the unit price of apparel exports from Bangladesh declined by 2.17% year-on-year, as reported by the National Board of Revenue, Bangladesh. Similarly, data from the Office of Textiles and Apparel (OTEXA) indicated that during the same period, apparel import prices from Bangladesh declined by 3.18% in the United States and 1.13% in the European Union, according to Eurostat (BGMEA, 2020).

Furthermore, supply chain disruptions originating from China significantly impacted the RMG industry in Bangladesh. China supplies over 50% of Bangladesh's apparel raw materials and approximately 40% of the machinery and spare parts required for garment production (Sharma et al., 2021a, 2021b). The halt in Chinese production led to severe raw material shortages, forcing many manufacturing units

in Bangladesh to suspend operations (Paul & Chowdhury, 2020). A recent study found that 93% of garment manufacturers in Bangladesh reported delays in raw material shipments during the pandemic, further exacerbating production challenges (Arnob et al., 2020). Additionally, disruptions in supply chain logistics, warehousing, shipment, and ordering networks resulted in a complete breakdown of the production process. These disruptions were compounded by ineffective policy management and delays in ensuring a steady supply of raw materials, further weakening the resilience of the RMG supply chain (Paul & Chowdhury, 2020).

2.4. Post-Pandemic Supply Chain Management Challenges and Opportunities

The pandemic disrupted global supply chains in unprecedented ways, leading to various challenges across industries, including the Ready-Made Garments (RMG) sector. However, these disruptions also presented opportunities for companies to innovate and build more resilient supply chain models. The post-pandemic recovery of supply chains has been marked by significant challenges, including financial constraints, operational disruptions, and the need for technological adaptation, (See Figure 4). The risks of bankruptcy and delays in payments have weakened supply chain relationships (Choi, 2020; Sen, 2020), while workforce reductions and structural adjustments have further complicated the recovery process (Chowdhury et al., 2020; Ishida, 2020). Moreover, the global economic downturn has slowed demand recovery and complicated strategic decision-making (Cui et al., 2019; Singh et al., 2020). Businesses also face obstacles in expanding production capacity, adopting new technologies, and enhancing supply chain resilience (Gurbuz & Ozkan, 2020; Sharma et al., 2021a, 2021b). Given the prolonged disruptions in supply and demand, achieving a sustainable and adaptive recovery remains a pressing concern (Clarke & Boersma, 2017; Lalon, 2020) (See Table 1).

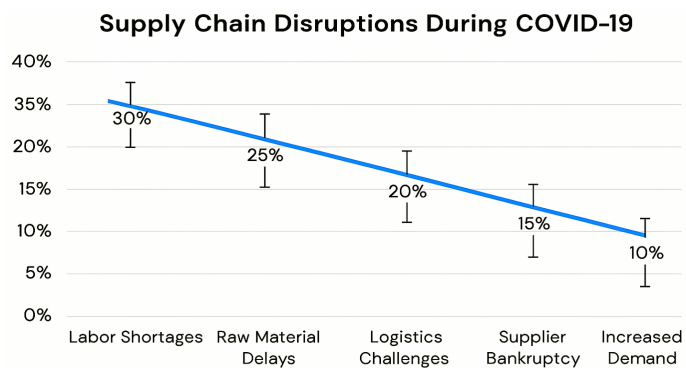


Figure 4. Supply chain disruptions during COVID-19.

Table 1. Post-pandemic SCM recovery challenges.

Author(s)	Challenges
Choi (2020)	Financial instability among supply chain partners leads to increased bankruptcy risks.

Continued

Chowdhury et al. (2020)	Workforce reductions, difficulties in restructuring supply chain networks, and challenges in maintaining supplier and buyer relationships.
Gurbuz and Ozkan (2020)	Necessity for rapid adoption of advanced technologies and adjustments in operational and managerial strategies.
Ishida (2020)	Industry-specific supply chain restructuring challenges and the need to maintain vertical integration for operational stability.
Clarke and Boersma (2017)	The prolonged recovery period is due to persistent disruptions in demand and supply, closure of key supply chain entities, and inadequate crisis preparedness.
Cui et al. (2019)	Extended global economic downturn and complexities in making strategic recovery decisions.
Lalon (2020)	Declining global demand, large-scale order cancellations, and the challenge of balancing economic viability with social sustainability.
Leite et al. (2020)	Limited resources for immediate recovery efforts and constraints in scaling up production capacity.
Majumdar et al. (2020)	Long-term demand contraction, emphasis on sustainable supply chain practices, delayed payments from buyers, and permanent shutdowns of supply chain partners.
Paul and Chowdhury (2020)	Challenges in expanding production capacity and ensuring the uninterrupted supply of raw materials.
Sen (2020)	Market downturn, delayed payments, reduction in sourcing alternatives, increased material costs, and frequent order cancellations.
Sharma et al. (2020)	Disruptions in demand patterns, necessity for flexible response strategies, realignment of supply chains, and integration of synchronized processes.
Sharma et al. (2021a, 2021b)	Inadequate infrastructure, lack of preparedness, and resource constraints hindering recovery efforts.
Singh et al. (2020)	Global recession leading to long-term economic instability and uncertainty in supply chain recovery.
van Hoek (2020)	Low adaptability to emerging distribution models, slow digital transformation, and insufficient readiness for post-pandemic recovery.

3. Methodology

This study adopts a mixed-methods research design, combining both primary and secondary data sources to examine the technological transformation of the Ready-Made Garment (RMG) supply chain in the post-pandemic context. The goal is to provide a comprehensive understanding of the impact of digital tools on supply chain efficiency, resilience, and sustainability.

3.1. Primary Data Collection

Primary data were gathered through structured surveys administered via Google

Forms. The questionnaire, developed through iterative refinement and pilot testing, comprised closed-ended items designed to capture industry professionals' perceptions regarding the integration of technologies such as ERP, AI, Blockchain, and IoT. Respondents were asked to assess post-pandemic technological interventions, environmental sustainability practices, and operational improvements across their organizations.

The sample consisted of 249 professionals with at least five years of experience in the RMG industry. Participants were drawn from diverse organizational roles, including supply chain management, operations, logistics, procurement, and technology implementation. To enhance the reliability and comparability of responses, uniform response scales were employed, and data collection was conducted over a two-month period.

While the sample size is substantial and includes experienced professionals from key RMG firms, it is important to acknowledge a potential limitation regarding representativeness. The sample may not fully capture insights from micro and small-scale enterprises, nor from geographically dispersed or informal segments of the industry. As such, the findings are most applicable to mid- and large-scale manufacturers operating within formalized RMG structures.

3.2. Secondary Data Collection

Secondary data were collected through a comprehensive review of scholarly literature, industry reports, and government publications. This review provided contextual grounding and theoretical support for the study's analytical framework. Sources included peer-reviewed academic journals, publications by trade associations such as the Bangladesh Garment Manufacturers and Exporters Association (BGMEA), and international policy briefs from institutions like the International Labour Organization (ILO) and UNCTAD.

3.3. Data Analysis

Quantitative survey responses were analyzed using descriptive and inferential statistical techniques to identify patterns, correlations, and trends in technology adoption and supply chain performance. Thematic analysis was applied to secondary data and open-ended responses to capture qualitative insights on challenges, strategies, and sectoral responses. This dual-layered approach enabled triangulation, enhancing the study's overall validity and depth.

Through this methodology, the research provides nuanced insights into how post-pandemic technological adoption is reshaping the operational architecture and strategic orientation of Bangladesh's RMG sector.

4. Theoretical Framework

The integration of digital technologies in the Ready-Made Garments (RMG) sector is primarily driven by increasing global competition, shifting buyer expectations, and the urgent need for post-pandemic supply chain resilience. Technolog-

ical innovation is no longer a differentiator but a strategic necessity for firms aiming to maintain operational efficiency and market relevance. This study adopts the Technology-Organization-Environment (TOE) framework as its guiding theoretical structure, providing a robust lens for analyzing the interdependencies between technological capabilities, internal readiness, and external pressures influencing technology adoption.

Empirical research has shown that countries such as China, Vietnam, Myanmar, and India have successfully leveraged automation and digital infrastructure to reduce lead times, optimize resource consumption, and enhance quality control (Pakurár et al., 2020). Consequently, the Bangladesh RMG industry faces rising pressure to emulate similar innovations to remain competitive within global supply chains. The TOE framework allows this study to situate technological transformation within the broader institutional, organizational, and sectoral dynamics shaping the RMG sector.

4.1. Sustainable Technology Adoption

The adoption of sustainable technologies defined as innovations that reduce environmental impact while improving operational performance is an increasingly prominent response to both competitive pressures and regulatory expectations. Under the technological dimension of the TOE framework, these include ERP systems for resource planning, IoT for monitoring energy and water usage, and Blockchain for traceability and emissions reporting.

As shown in **Figure 5**, sustainable technology adoption is influenced by multiple drivers: environmental regulations, market competition, and buyer compliance mandates. Green innovations such as waterless dyeing, digital textile printing, and RFID-integrated logistics systems exemplify how firms can achieve both environmental performance (e.g., reduced emissions and waste) and financial performance (e.g., cost savings and process efficiency).

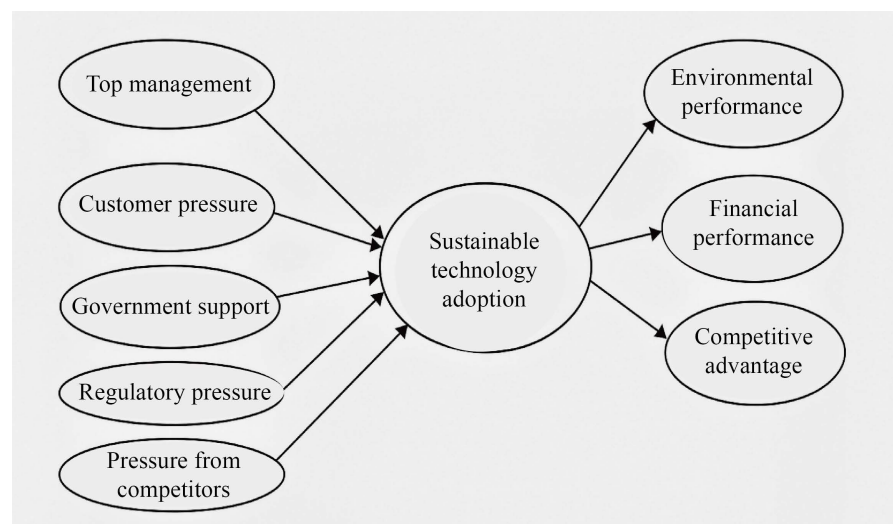


Figure 5. Sustainable technology adoption model (adapted from Wang & Yu, 2020).

According to Wang & Yu (2020), businesses adopting sustainable technology not only reduce operational externalities but also strengthen their market position and long-term viability. These innovations serve as core enablers of supply chain resilience, particularly in a post-pandemic era where responsiveness, flexibility, and accountability are essential.

Furthermore, under the organizational context of TOE, firms with advanced management systems, skilled human capital, and leadership commitment to sustainability are more likely to adopt these technologies effectively. The study’s findings affirm that ERP and IoT tools are more widely used by firms with structured environmental and quality management programs (See Figure 5).

4.2. Business Structure and Raw Material Suppliers

The environmental context of the TOE model incorporates external stakeholder influence including suppliers, customers, regulatory institutions, and global buyers which plays a pivotal role in shaping the digital transformation of the RMG supply chain.

As illustrated in Figure 6, the RMG supply chain is structured around key stakeholders: local and foreign raw material suppliers, garment manufacturers, and global buyers. Information flow and material flow are interdependent; thus, any disruption or inefficiency at the supplier or logistics node impacts the entire chain. Technological systems such as Blockchain and IoT enable synchronized tracking of inputs and outputs, facilitating improved forecasting, just-in-time production, and traceability.

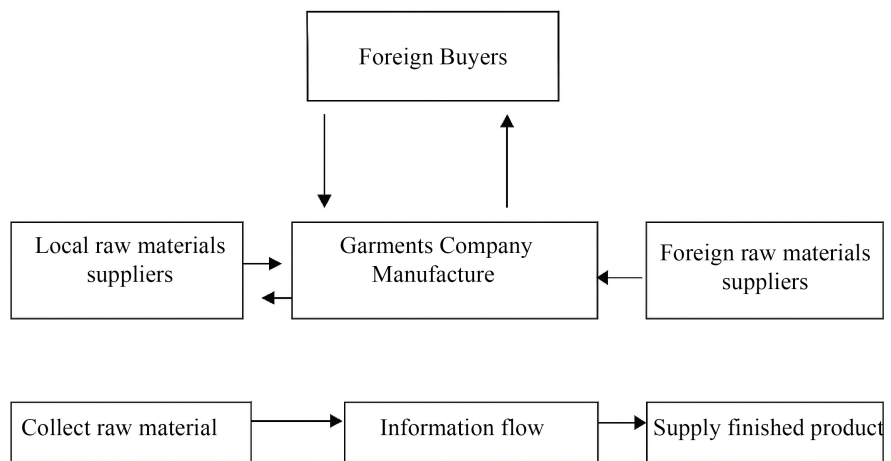


Figure 6. Business Structure and Raw Material Suppliers (Adapted from Wang & Yu, 2020).

Technology also enhances supplier relationship management. For instance, ERP systems allow firms to digitally coordinate with multiple vendors, manage procurement contracts, and maintain quality control documentation. Meanwhile, IoT devices and RFID sensors provide real-time visibility into inventory and shipment status, reducing the risk of stockouts or delays key concerns during the pan-

demic-induced disruptions.

These transformations are particularly relevant as Bangladesh moves toward compliance-heavy sourcing environments, where buyer expectations increasingly include supply chain transparency, ethical labor sourcing, and carbon footprint accountability.

4.3. Conceptual Alignment and Theoretical Justification

The TOE framework integrates the study's empirical and conceptual dimensions by articulating how:

i Technological innovations (ERP, AI, IoT, Blockchain) offer functional tools to support sustainability and resilience; ii. Organizational readiness (skills, leadership, infrastructure) determines the capacity to implement these tools; and iii. Environmental pressures (regulation, buyer expectations, competitive dynamics) create external incentives and constraints shaping firm behavior.

This theoretical integration not only provides analytical clarity but also ensures that the conceptual model presented in Section 5 is grounded in a well-established body of innovation adoption literature. The TOE framework, supplemented by sustainability adoption theory (Wang & Yu, 2020), positions technology as both an enabler of supply chain resilience and a response to broader institutional imperatives in the RMG industry.

5. Conceptual Framework

The conceptual framework developed in this study draws on the Technology-Organization-Environment (TOE) theoretical structure to illustrate how digital technologies are integrated into the RMG supply chain and how they affect operational performance, sustainability, and resilience. This framework is informed by empirical data collected through the survey of 249 industry professionals and contextualized through the broader literature on digital supply chain transformation in emerging economies.

The model depicts a multi-tiered system where technological interventions interact with organizational capabilities and environmental pressures to produce systemic improvements across key supply chain stages ranging from design and sourcing to production, distribution, and post-delivery transparency (See **Figure 7**).

5.1. Dimensions of the Conceptual Framework

Technological Dimension

The technologies considered in this model ERP, AI, IoT, and Blockchain serve as the primary enablers of transformation:

i. ERP centralized procurement, inventory, and scheduling functions, improving coordination; ii. AI is employed for predictive analytics, demand forecasting, and defect detection; iii. IoT enables real-time monitoring of machinery, inventory, and shipment logistics; iv. Blockchain ensures transparency, traceability, and

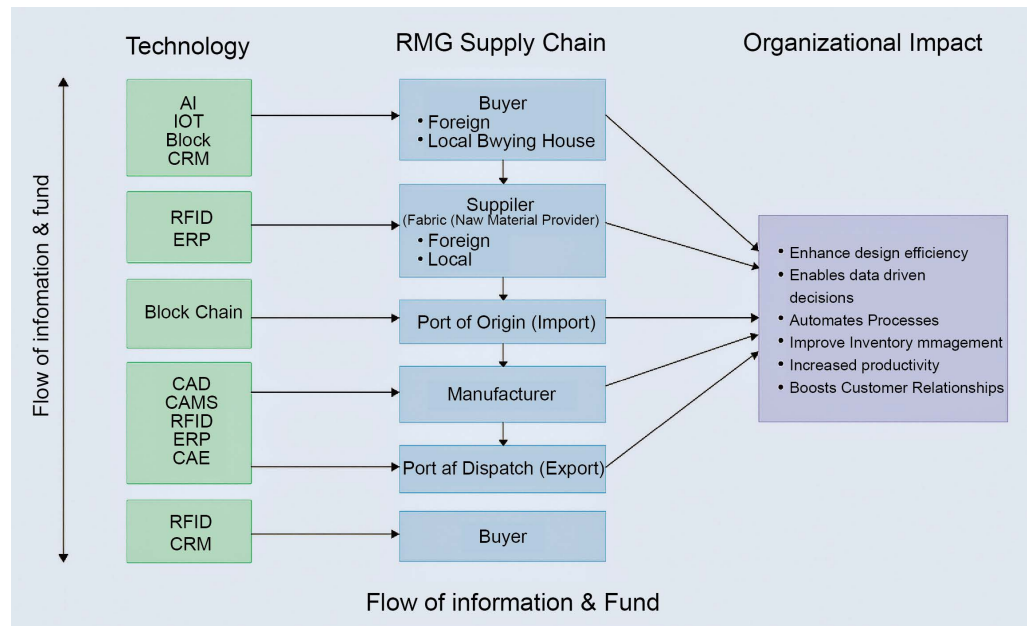


Figure 7. Conceptual model of technology-driven supply chain management in RMG sector.

ethical compliance from sourcing to delivery. These technologies address distinct bottlenecks across the RMG value chain and, when implemented synergistically, significantly enhance agility and resilience.

Organizational Dimension

Firm-specific internal factors such as: i. Digital infrastructure; ii. Managerial commitment; iii. Workforce capability; iv. Previous ICT adoption experience affect the readiness to adopt and scale these technologies. Survey results indicate that firms with cross-functional ERP teams, IT-trained supervisors, and sustainability-oriented leadership are more likely to integrate complex technologies like Blockchain and AI into their workflows.

Environmental Dimension

External pressures from: i. International buyers; ii. Regulatory compliance bodies; iii. Trade associations (e.g., BGMEA); iv. Industry competition and global norms function as both motivators and constraints. Increasingly, global brands require digital traceability, ESG reporting, and short lead times, prompting firms to align technological upgrades with export market requirements.

5.2. Digital Flow across the RMG Supply Chain

The conceptual framework maps the technology-enabled flow of information and materials from raw material suppliers to international buyers. At each stage, specific technologies enhance transparency, efficiency, and performance outcomes (See **Table 2**).

This framework captures both linear material flow and real-time feedback loops, with IoT and AI generating data streams that inform upstream decisions, improving supply chain responsiveness and sustainability metrics.

Table 2. Technology integration across the RMG supply chain: key actors, tools, and impact.

Stage	Key Actors	Technologies Applied	Impact
Design & Planning	Buyers, Local Buying Houses	AI, Big Data Analytics	Forecast accuracy, custom design coordination
Sourcing	Local/International Suppliers	ERP, Blockchain	Procurement speed, traceability, ethical sourcing
Production	Manufacturers	ERP, AI, IoT, RFID	Real-time tracking, defect reduction, lean ops
Logistics	Ports, Logistics Providers	IoT, ERP, RFID	Shipment visibility, route optimization
Delivery & Post-Sale	Buyers, Auditors	Blockchain, CRM	Compliance, auditability, customer engagement

5.3. Strategic Outcomes and Alignment

The integration of technology across these domains generates cumulative benefits: i. Operational Efficiency: Reduced cycle times, minimized inventory holding, automated production; ii. Resilience: Improved risk detection, multi-source flexibility, predictive scenario planning; iii. Sustainability: Emission tracking, water usage optimization, ethical labor verification.

These outcomes support the post-pandemic imperative for agile, transparent, and sustainable supply chains, validating the TOE framework's suitability for guiding transformation in emerging-market industries such as Bangladesh's RMG sector.

This conceptual framework informs the interpretation of empirical findings presented in Section 6 and serves as a roadmap for practitioners and policymakers seeking to enhance digital maturity, supply chain resilience, and environmental compliance in the global garment industry.

6. Findings and Discussions

This section presents a comprehensive analysis of the empirical findings derived from structured surveys administered to 249 experienced professionals in Bangladesh's Ready-Made Garment (RMG) sector, in conjunction with secondary literature and industry reports. Quantitative data were analyzed using descriptive and inferential statistical techniques, while thematic analysis was employed to extract patterns and interpret context from qualitative responses and secondary sources. The discussion is organized into five subsections: 1) technology adoption patterns, 2) operational performance outcomes, 3) sustainability alignment, 4) implementation challenges, and 5) enabling factors and strategic opportunities.

6.1. Patterns of Technology Adoption

Descriptive analysis revealed that Enterprise Resource Planning (ERP) systems are the most widely adopted technology among RMG firms, implemented by 68.3%

of survey respondents. Internet of Things (IoT) applications followed with a 47.4% adoption rate, while Artificial Intelligence (AI) and Blockchain technologies were reported at 31.2% and 24.5%, respectively. Cross-tabulation indicated a significant association between firm size and the level of technological adoption ($\chi^2(2) = 14.87, p < 0.01$), suggesting that larger firms possess a greater propensity to adopt complex digital tools due to economies of scale and investment capacity.

These findings align with the literature (Di Vaio et al., 2023; Pakurár et al., 2020), which notes that large manufacturers typically lead digital transformation initiatives due to stronger infrastructure, global buyer pressure, and formalized governance systems.

6.2. Operational Performance Improvements from Digital Technologies

To measure the impact of digital tools on key supply chain performance indicators, survey respondents evaluated changes in lead times, defect rates, inventory accuracy, and coordination efficiency on a 5-point Likert scale.

ERP Systems

Participants who reported ERP adoption indicated a mean lead time reduction of 13.2% and a 24.5% increase in order fulfillment accuracy ($M = 4.32, SD = 0.68$). ANOVA testing showed a statistically significant difference in operational efficiency scores across firms using ERP versus those without ($F(1, 247) = 9.67, p < 0.01$).

AI Applications

AI-enabled forecasting and visual inspection tools yielded substantial benefits in quality management. Over 41% of respondents using AI reported improved consistency in defect detection, with automated systems achieving accuracy levels exceeding manual inspections. Predictive analytics tools were cited for optimizing raw material procurement by correlating past order data with projected buyer demand.

IoT Systems

IoT-based tracking systems were associated with enhanced inventory visibility and machinery efficiency. 53% of respondents indicated measurable reductions in energy and water consumption, linked to automated environmental sensors on the production floor. Warehouse automation through RFID was highlighted for reducing human error and accelerating order dispatching processes.

Blockchain

Although blockchain implementation remains nascent, respondents who piloted such systems reported improved traceability, especially for compliance with buyer audits related to ethical sourcing and labor transparency. Blockchain was also mentioned for reducing transaction delays by automating invoicing and shipment milestones through smart contracts. These findings collectively demonstrate that technology adoption is positively correlated with measurable improvements in supply chain coordination, forecasting precision, and resource optimization.

6.3. Environmental Sustainability and Technological Synergies

Sustainability-driven technology usage emerged as a major post-pandemic priority. 72% of participants affirmed that digital tools facilitated compliance with environmental regulations and buyer-led ESG mandates. Notably, IoT systems enabled granular monitoring of emissions and energy usage, while ERP modules allowed for optimized material flow and reduction in overproduction.

Blockchain was cited as enabling full lifecycle transparency, from fiber origin (e.g., organic cotton certifications) to labor verification, enabling RMG exporters to satisfy external audits from major retailers and third-party organizations such as WRAP and the Higg Index. Qualitative comments also emphasized the strategic use of digital printing and waterless dyeing as innovations aligned with sustainability and cost-efficiency.

These findings are consistent with Wang & Yu (2020) and Mamun Habib et al. (2024), who argued that sustainable technology adoption leads to not only improved environmental outcomes but also enhanced financial performance via operational efficiencies.

6.4. Barriers to Technology Integration: Operational, Technical, and Organizational

Despite the observed advantages, widespread technology integration is hindered by persistent structural and institutional challenges. Survey participants were asked to rank major barriers on a five-point scale. The most frequently cited constraints include (See Table 3):

Table 3. Key barriers to digital technology adoption in the RMG sector.

Barrier	% of Respondents
High capital investment requirements	65.4%
Digital skills shortage	58.1%
Inadequate infrastructure (e.g., power, net)	61.7%
Data privacy and cybersecurity risks	47.8%
Interoperability with legacy systems	43.2%

Regression analysis confirmed that investment barriers had the strongest negative correlation ($\beta = -0.37, p < 0.01$) with full-suite technology adoption, followed by digital literacy ($\beta = -0.26, p < 0.05$). Qualitative comments emphasized difficulties in aligning legacy ERP platforms with newer blockchain or cloud-based tools, particularly among subcontractors and small-scale suppliers operating outside major industrial zones.

Moreover, participants noted limited access to government-funded incentives or technical support, especially among non-exporting SMEs.

6.5. Strategic Enablers and Post-Pandemic Opportunities

Despite these challenges, the pandemic has served as a digital inflection point for

the RMG sector. Survey responses, corroborated by literature (ILO, 2021; Ivanov & Dolgui, 2020), identified several enabling factors that can accelerate sector-wide transformation:

Policy Support: Government programs under Digital Bangladesh 2030 and partnerships with international donors (e.g., ILO-SEIP) are expanding access to ICT infrastructure and vocational training.

Buyer Incentives: Increasingly, international buyers require traceability and compliance systems, making technology adoption a precondition for sustained export orders.

Industry Collaboration: Collaborative digital platforms such as shared ERP environments managed by BGMEA or tech consortiums are emerging to reduce implementation costs through resource pooling.

Respondents also highlighted that post-pandemic buyer behavior has shifted toward flexible sourcing, short-lead-time models, and compliance-based partnerships, all of which favor digitally mature firms.

The empirical evidence confirms that digital transformation is both a strategic necessity and an operational catalyst for the RMG sector. Technologies such as ERP, AI, IoT, and blockchain provide measurable gains in process control, resource utilization, and compliance. However, adoption remains uneven, particularly across smaller firms and subcontracting networks, where infrastructural and knowledge barriers persist. A targeted policy approach, emphasizing digital inclusivity and capacity-building, will be essential to scaling these innovations industry-wide.

The findings validate the proposed conceptual and theoretical frameworks, demonstrating that technological advancement, when enabled by supportive organizational and environmental conditions, significantly enhances supply chain resilience, adaptability, and sustainability in post-crisis contexts.

7. Conclusion

The COVID-19 pandemic exposed critical vulnerabilities within Bangladesh's Ready-Made Garment (RMG) supply chain, underscoring the urgent need for technological modernization, operational resilience, and sustainable practices. This study examined the post-pandemic technological transformation of the RMG sector using a mixed-methods approach, combining primary data from 249 experienced industry professionals with secondary sources from academic and policy literature.

Findings demonstrate that the adoption of digital technologies, particularly ERP, AI, IoT, and Blockchain, has yielded tangible improvements across supply chain performance metrics. ERP systems have enhanced coordination and resource planning; AI tools have improved forecasting and quality assurance; IoT applications have enabled real-time monitoring of production and logistics; and blockchain platforms, though still in early stages, are strengthening transparency and ethical compliance. Descriptive and inferential statistical analyses confirmed

that technology adoption is strongly associated with improvements in lead times, order accuracy, defect reduction, and environmental accountability.

The study applied the Technology-Organization-Environment (TOE) framework to contextualize adoption patterns. It found that technological capability alone does not ensure transformation organizational readiness (e.g., digital skills, infrastructure) and environmental pressures (e.g., buyer mandates, regulatory expectations) play equally critical roles. Despite growing digital momentum, implementation challenges persist, including high capital costs, inadequate infrastructure, cybersecurity concerns, and interoperability issues with legacy systems.

Nonetheless, the post-pandemic environment presents significant opportunities. Increased buyer demand for traceability and ESG compliance, along with government-led digitization initiatives and skill development programs, are accelerating the pace of transformation across the sector. As the RMG industry seeks to maintain its global competitiveness, scalable and inclusive digital adoption must remain a strategic priority.

This study offers important implications for policymakers, practitioners, and international buyers. Policymakers must prioritize infrastructure investment, digital capacity-building, and inclusive support mechanisms for SMEs. Firms must approach digital transformation holistically investing not just in tools but in people, processes, and partnerships. Global buyers, meanwhile, can serve as enablers by offering incentive-based compliance models and long-term digital alignment support.

Limitations and Future Research

While this study provides valuable insights, it is not without limitations. The survey sample, though robust, was primarily composed of professionals from formal and medium-to-large firms. As such, the perspectives of micro-enterprises and subcontractors may be underrepresented. Future research should extend this analysis across a more diverse range of supply chain actors, including informal and rural production clusters. Moreover, longitudinal studies would offer deeper insights into the long-term performance outcomes of digital adoption and its resilience under future disruptions.

Ultimately, this research affirms that technology is not only transforming supply chain mechanics but is also reshaping the strategic architecture of the RMG sector. A digitally enabled, sustainable, and resilient supply chain is not only desirable, it is essential for the industry's future.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- Ahmed, F., Islam, M. A., & Hasan, S. (2021). Digital Transformation in Bangladesh's RMG Sector: Challenges and Opportunities. *Journal of Business and Management*, *15*, 45-60.
- Arnob, S. H., Atik, R. I., Ahmed, M. A., & Hassan, S. M. (2020). Lead Time Optimization of RMG Sector Supply Chain in Bangladesh. *Supply Chain Insider*, *4*, 1-6.
- Baryannis, G., Validi, S., Dani, S., & Antoniou, G. (2019). Supply Chain Risk Management and Artificial Intelligence: State of the Art and Future Research Directions. *International Journal of Production Research*, *57*, 2179-2202. <https://doi.org/10.1080/00207543.2018.1530476>
- BGMEA (2020). *COVID-19 and Bangladesh's RMG industry: Challenges and Responses*. Bangladesh Garment Manufacturers and Exporters Association. <https://www.bgmea.com.bd>
- Choi, T. (2020). Innovative "Bring-Service-Near-Your-Home" Operations under Corona-Virus (COVID-19/SARS-CoV-2) Outbreak: Can Logistics Become the Messiah? *Transportation Research Part E: Logistics and Transportation Review*, *140*, Article ID: 101961. <https://doi.org/10.1016/j.tre.2020.101961>
- Chowdhury, M. T., Sarkar, A., Paul, S. K., & Muktadir, M. A. (2020). A Case Study on Strategies to Deal with the Impacts of COVID-19 Pandemic in the Food and Beverage Industry. *Operations Management Research*, *15*, 166-178. <https://doi.org/10.1007/s12063-020-00166-9>
- Clarke, T., & Boersma, M. (2017). The Governance of Global Value Chains: Unresolved Human Rights, Environmental and Ethical Dilemmas in the Apple Supply Chain. *Journal of Business Ethics*, *143*, 111-131. <https://doi.org/10.1007/s10551-015-2781-3>
- Cui, L., Chan, H. K., Zhou, Y., Dai, J., & Lim, J. J. (2019). Exploring Critical Factors of Green Business Failure Based on Grey-Decision Making Trial and Evaluation Laboratory (Dematel). *Journal of Business Research*, *98*, 450-461. <https://doi.org/10.1016/j.jbusres.2018.03.031>
- Di Vaio, A., Latif, B., Gunarathne, N., Gupta, M., & D'Adamo, I. (2023). Digitalization and Artificial Knowledge for Accountability in SCM: A Systematic Literature Review. *Journal of Enterprise Information Management*, *37*, 606-672. <https://doi.org/10.1108/jeim-08-2022-0275>
- Gurbuz, I. B., & Ozkan, G. (2020). Transform or Perish: Preparing the Business for a Post-pandemic Future. *IEEE Engineering Management Review*, *48*, 139-145. <https://doi.org/10.1109/emr.2020.3014693>
- International Labour Organization (ILO) (2021a). *COVID-19 and the Textiles, Clothing, Leather and Footwear Industries*. https://www.ilo.org/sector/Resources/publications/WCMS_741344/lang--en/index.htm
- Ishida, S. (2020). Perspectives on Supply Chain Management in a Pandemic and the Post-COVID-19 Era. *IEEE Engineering Management Review*, *48*, 146-152. <https://doi.org/10.1109/emr.2020.3016350>
- Ivanov, D. (2021). Supply Chain Viability and the COVID-19 Pandemic: A Conceptual and Formal Generalisation of Four Major Adaptation Strategies. *International Journal of Production Research*, *59*, 3535-3552. <https://doi.org/10.1080/00207543.2021.1890852>
- Ivanov, D., & Dolgui, A. (2020). Viability of Intertwined Supply Networks: Extending the

- Supply Chain Resilience Angles Towards Survivability. A Position Paper Motivated by COVID-19 Outbreak. *International Journal of Production Research*, 58, 2904-2915. <https://doi.org/10.1080/00207543.2020.1750727>
- Khan, Z. H., Islam, G. M. N., & Habib, M. M. (2023). Technology-Driven Supply Chain Management in Readymade Garments: A Literature Review. *International Supply Chain Technology Journal*, 9, 10-10. <https://doi.org/10.20545/isc tj.v09.i05.01>
- Lalon, R. M. (2020). COVID-19 vs Bangladesh: Is It Possible to Recover the Impending Economic Distress Amid This Pandemic? *Journal of Economics and Business*, 3, 825-8236. <https://doi.org/10.31014/aior.1992.03.02.240>
- Leite, H., Lindsay, C., & Kumar, M. (2020). COVID-19 Outbreak: Implications on Healthcare Operations. *The TQM Journal*, 33, 247-256. <https://doi.org/10.1108/tqm-05-2020-0111>
- Majumdar, A., Shaw, M., & Sinha, S. K. (2020). COVID-19 Debunks the Myth of Socially Sustainable Supply Chain: A Case of the Clothing Industry in South Asian Countries. *Sustainable Production and Consumption*, 24, 150-155. <https://doi.org/10.1016/j.spc.2020.07.001>
- Mamun Habib, M., Sabah, S., Chowdhury, F., Raisa, R., & Shuvo, T. F. (2024). Technology Enabled Ready-Made Garments Supply Chain Management: A Literature Review. *Revista de Gestão Social e Ambiental*, 18, e08842. <https://doi.org/10.24857/rgsa.v18n10-188>
- Nipa, N. J. (2020). Validating Existing ICT Infrastructure of RMG Sector: A Study on Bangladesh. *International Journal of Industrial and Manufacturing Systems Engineering*, 5, 28-38. <https://doi.org/10.11648/j.ijimse.20200503.11>
- Pakurár, M., Czeglédi, C., & Juhász, P. (2020). Supply Chain Digitalization: Challenges and Opportunities. *Logistics and Transport*, 54, 145-167.
- Paul, S. K., & Chowdhury, P. (2020). A Production Recovery Plan in Manufacturing Supply Chains for a High-Demand Item during COVID-19. *International Journal of Physical Distribution & Logistics Management*, 51, 104-125. <https://doi.org/10.1108/ijpdlm-04-2020-0127>
- Sen, S. (2020). The unprecedented Pandemic “COVID-19” Affected Apparel Workers by Shivering the Apparel Supply Chain. *Journal of Textile and Apparel, Technology and Management*, 11, 1-20.
- Sharma, A., Adhikary, A., & Borah, S. B. (2020). COVID-19’s Impact on Supply Chain Decisions: Strategic Insights from NASDAQ 100 Firms Using Twitter Data. *Journal of Business Research*, 117, 443-449. <https://doi.org/10.1016/j.jbusres.2020.05.035>
- Sharma, A., Borah, S. B., & Moses, A. C. (2021a). Responses to COVID-19: The Role of Governance, Healthcare Infrastructure, and Learning from Past Pandemics. *Journal of Business Research*, 122, 597-607. <https://doi.org/10.1016/j.jbusres.2020.09.011>
- Sharma, M., Luthra, S., Joshi, S., & Kumar, A. (2021b). Developing a Framework for Enhancing Survivability of Sustainable Supply Chains during and Post-COVID-19 Pandemic. *International Journal of Logistics Research and Applications*, 24, 453-474.
- Singh, S., Kumar, R., Panchal, R., & Tiwari, M. K. (2020). Impact of COVID-19 on Logistics Systems and Disruptions in Food Supply Chain. *International Journal of Production Research*, 59, 1993-2008. <https://doi.org/10.1080/00207543.2020.1792000>
- Tanvir, S. I., & Muqaddim, N. (2013). Supply Chain Management Offering the New Paradigm for Bangladesh Garment Industry. *Journal of Economics and Sustainable Development*, 4.
- van Hoek, R. (2020). Research Opportunities for a More Resilient Post-COVID-19 Supply Chain—Closing the Gap between Research Findings and Industry Practice. *International Journal of Operations & Production Management*, 40, 341-355.

<https://doi.org/10.1108/ijopm-03-2020-0165>

Wang, Z., & Yu, C. (2020). Flexible Recovery Strategies for Supply Chain Disruptions. *Journal of Business Research*, 109, 275-290.