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# Barriers to Blockchain Adoption in Supply Chain Management in the RMG Sector of Bangladesh

**Atika Ashraf Akhi**
Industrial & Production Engineering
Rajshahi University of Engineering & Technology
Rajshahi, Bangladesh
2105056@student.ruet.ac.bd

**Razoan Islam Zihad**
Industrial & Production Engineering
Jashore University of Science & Technology
Jashore-7408, Bangladesh
razoanislamzihad@gmail.com

**Khaleda Yeasmin Mim**
Electrical and Electronic Engineering
Jashore University of Science & Technology
Jashore-7408, Bangladesh
yeasmin.mim18@gmail.com

**Md. Nazmus Sakib**
Computer Science and Engineering
Bangladesh University of Engineering and Technology
Dhaka, Bangladesh
2105102@ugrad.cse.buet.ac.bd

**Shoyeb Muhammad**
Gunma University
Kiryu, Gunma, Japan
s.muhammad@just.edu.bd

## Abstract

The ready-made Garments (RMG) sector of Bangladesh is the country's largest export earner and second-largest global apparel exporter after China. Despite its important economic role, this sector has long been plagued by supply chain management (SCM) issues, including transparency, inefficiency and adherence. Blockchain Technology (BT) has emerged as a promising solution to these challenges for its potential by improving traceability, security and trust among supply chain stakeholders. Although most research has focused on economic and safety-related issues, few studies have applied the Technology-Organization-Environment (TOE) framework to examine barriers to BT adoption, highlighting a research gap for sustainable and long-term competitiveness in the RMG sector. This study addresses this gap by identifying ten key barriers through a literature review with expert surveys from the RMG industry and academic circles. Further, the construction is modeled using the Best-Worst Method (BWM) to determine the relative importance of identified barriers, while the Graph Theory and Matrix Approach (GTMA) is used to model interrelationships and rank them systematically. The findings show that Technological barriers are the most critical impediment of BT adoption in the SCM of Bangladesh's RMG sector. The results provide valuable guidance to decision-makers, industrial leaders, and policymakers to formulate long-term strategies for facilitating BT adoption in the RMG sector and improving its overall supply chain efficiency. This exploratory study leads to a set of research propositions and scope for future investigation on technology adoption in emerging markets.

## Keywords
Blockchain technology, RMG sector, TOE framework, Best-Worst Method (BWM), Graph Theory Matrix Approach

## 1. Introduction
The ready-made garments (RMG) industry is the backbone of Bangladesh's economy. It generates most of the country's export earnings, employs millions of workers, and supplies apparel products worldwide. In 2024, the country exported garments worth approximately US$38.48 billion. It accounts for more than 84% of national export earnings and maintains its position as the world's second-largest apparel exporter after China (Swazan and Das 2022) (Tijan et al. 2019). Yet, the supply chain behind this success remains complicated and fragmented. Many factories still rely on disconnected systems, paper records and limited which slows operations and raises concerns about ethics, sustainability and compliance. In this situation, blockchain technology (BT) has emerged as a possible solution to the supply chain problems.

Blockchain acts as a secure and unchangeable digital ledger, enabling all stakeholders to record, share and verify information efficiently throughout the supply chain. For the RMG industry, blockchain can track raw materials, monitor production processes, log compliance data and trace finished products from origin to delivery. Smart contracts further automate processes such as delivery confirmation and payment, reducing delays, minimizing fraud and decreasing reliance on third-party audits(Saberi et al. 2019). While many leading international apparel brands have successfully adopted blockchain to improve traceability and transparency(Saberi et al. 2019), Bangladesh still faces significant challenges. These include limited digital infrastructure, resistance to organizational change, unclear regulations and high implementation costs. So, it is high time we take necessary initiatives to study and solve problems to adopt blockchain technology (Figure 1).

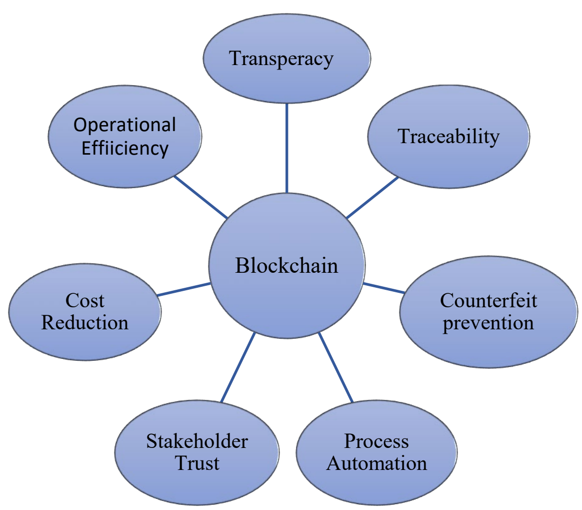


Figure 1. The advantages of BT adoption in the RMG industry

Figure 1 shows the main benefits of using blockchain technology in the RMG sector. At the center is blockchain, which acts as a secure and transparent digital ledger. At the center is blockchain, which acts like a secure and transparent digital ledger. Around it are six important advantages: Transparency helps everyone see what's happening across the supply chain, while Traceability and Origin Tracking make it easy to follow materials and products from start to finish. Counterfeit Prevention protects against fake goods, and Process Automation speeds up tasks by reducing paperwork. These benefits together improve operational efficiency, build Stakeholder Trust and reduce costs by making the entire supply chain more efficient and reliable.

Most research on blockchain adoption focuses on economic or security issues, often missing the unique challenges faced by emerging economies like Bangladesh. The Technology-Organization-Environment (TOE) framework helps break down these barriers into technological, organizational and environmental factors that a clear and practical way to understand what holds back blockchain adoption. (Hadi Almaher et al. 2024, Tornatzky and Fleischer 1990). This study applies the Best Worst Method (BWM) to rank the relative importance of barriers and the Graph Theory and Matrix Approach (GTMA) to model their interconnections. BWM helps experts prioritize barriers through pairwise comparisons while GTMA treats each barrier as a network node to identify the most influential challenges. The analysis finds that technological barriers are the biggest challenge but issues with management and the environment also matter a lot.

In summary, this research highlights the main barriers to blockchain technology adoption. It offers a deeper understanding of technology adoption in emerging economies. Addressing these challenges is essential for improving operational efficiency, promoting sustainability and strengthening Bangladesh's position in the global market of this sector.

### 1.1 Motivation of the research

Bangladesh's RMG sector relies on a complex supply chain that still faces challenges with transparency and reliable data. As global buyers increasingly demand proof of ethical and sustainable practices therefore these gaps pose significant risks for the industry. Although BT could help but adoption has been slow and the real reasons are not fully understood. This research is motivated by the need to identify these barriers, understand which ones matter most and provide practical guidance to help the RMG supply chain move toward greater trust, efficiency and global competitiveness.

### 1.2 Objectives

- Identify the technological, organizational and environmental barriers to Blockchain Technology (BT) integration in the supply chain management of the Bangladesh RMG sector by using the TOE framework.
- Evaluate and rank identified barriers with the Best-Worst Method (BWM).
- Model and analyze the interrelationships and influence among the barriers using Graph Theory and Matrix Approach (GTMA).
- Offer practical recommendations for policymakers, industry leaders and supply chain managers to overcome critical barriers and support blockchain integration in RMG supply chain operations.

### 1.3 Scope of the study

This study is designed to bridge this crucial research gap. We use a careful method that combines a detailed literature review with surveys from experts in both the RMG industry and academic circles. It identifies ten key barriers to blockchain adoption in supply chain management and uses the Best–Worst Method and Graph Theory and Matrix Approach to rank their importance and relationships. The findings show that technological barriers are the most critical, offering clear, evidence-based guidance for policymakers and industry leaders. This analysis will help in developing specific, long-term strategies needed to support BT adoption and improve the entire supply chain.

### 1.4 Research significance:

This research provides practical guidance for policymakers and industry leaders to address barriers to enhance transparency, traceability and efficiency in the RMG supply chain. From an academic standpoint, the study fills an important gap by bringing together the TOE framework, BWM and GTMA methods to provide a structured and thorough view of blockchain adoption in an emerging market setting. In doing so, it creates a solid foundation for future studies and supports more informed strategic decision-making in the sector.

## 2. Literature Review

Blockchain technology offers much potential for improving supply chain traceability, transparency and the overall level of trust (Habib et al. 2025) (Al Amin and Baldacci 2024). It achieves this by meticulously recording the provenance of goods and automating transactions through the use of smart contracts (Al Amin and Baldacci 2024). While major apparel pilot programs, such as the IBM Food Trust and the Higg Index, have demonstrated the value of this technology—particularly for ethical sourcing—adoption remains limited within Bangladesh (Habib et al. 2025). This is despite renewed interest following the COVID-19 pandemic, which sharply exposed the fragility of the supply chain in the country's Ready-Made Garment (RMG) sector, a field that accounts for over 80% of all national exports (Habib et al. 2025).

To provide a current understanding of blockchain adoption, this study conducted a comprehensive literature gap from 2020 to 2025, covering both academic and industry sources. The review highlights recent academic and industry findings on adoption trends, challenges, and pilot programs in the RMG sector.Literature reviews find TAM, UTAUT, DOI and the TOE framework commonly used to study blockchain adoption; reviewers recommend also considering task–technology fit because blockchain's properties may not align with routine tasks (Wong et al. 2024) (Kouhizadeh et al. 2021) (Kouhizadeh et al. 2021). The most common global hurdles are complex systems, interoperability issues, high expenses, a dearth of standards, and ambiguous regulation. In emerging economies, these problems intensify, compounded by poor infrastructure and weak institutional backing (Anam et al. 2025) (Al Amin and Baldacci 2024) (Elkoraichi et al. 2025a).

Empirical studies in Bangladesh highlight specific impediments: a fuzzy DEMATEL study on pharmaceuticals cites integration complexity, data security/storage concerns, and inadequate IT infrastructure as top obstacles(Anam et al. 2025). Nayeem et al. (2025) reduced the barriers for FMCG supply chains from nineteen to ten, identifying poor collaboration, immature technology, weak leadership support, and limited data sharing as key(Nayeem et al. 2025). When looking at the RMG industry, surveys show that roughly 24.5% of firms have run blockchain pilots. While these efforts improved traceability, aligning the legacy systems used by small subcontractors with the new platforms is proving difficult (Habib et al. 2025) (Al Amin and Baldacci 2024).

Looking at barriers to implementation, studies tend to group them using the TOE (Technology-Organization-Environment) framework. This gives us three main categories to work with:

1. **Technological Challenges**: The technology side presents multiple issues—poor digital infrastructure in many regions, not enough people with the right technical skills, and the headache of getting new systems to work alongside old ones (Anam et al. 2025).
2. **Organizational Hurdles**: Problems inside companies are equally troublesome. Many managers don't really understand what blockchain can do, there's natural resistance when people are asked to change how they work, and without strong support from top management these projects tend to stall(Nayeem et al. 2025).
3. **Environmental Pressures**: Outside forces matter too. Governments haven't provided clear rules yet, there's hardly any financial incentives to encourage adoption, and the costs involved create real barriers for smaller players (Elkoraichi et al. 2025b).

What comes through in the research is somewhat contradictory—blockchain could genuinely transform how the RMG industry operates, but getting there isn't just about having the right technology. The social and organizational challenges are just as critical, maybe even more so in some cases. Successful diffusion needs technological solutions, organizational change, and supportive policy. Noting a research gap in systematically ranking and mapping these interdependent barriers in Bangladesh's RMG context, this study applies BWM and GTMA to weigh and model the TOE barriers identified above (Kouhizadeh et al. 2021).

## 3. Methodology

To systematically investigate blockchain adoption barriers in the RMG sector, this study combines the **Technology-Organization-Environment (TOE) framework** with two multi-criteria decision-making tools. They are:

i) Best-worst method ii) Graph Theory Matrix Approach

## 3.1 Best-worst method (BWM)

BWM was proposed as an MCDM tool for making up criteria (Muhammad et al. 2024). If we have x factors and we would like to compare those in an attached manner on a scale of 1 to 9, the final matrix would be

Definition 1: Let i be the best element and j be the worst element; then, comparison $\mathbf{a}_{ij}$ is defined as a reference comparison (Muhammad et al. 2024).

Definition 2: By contrast, if $\mathbf{a}_{ij} \geq 1$ and neither i nor j are the greatest or worst items, then aij is characterized as a secondary comparison (Muhammad et al. 2024).

### 3.1.1 Steps of BWM

The step of BWM that can be used to determine the weights of the barriers are discussed in this section.

**Step 1:** Select barrier settings.

**Step 2:** Selecting the best and the worst ones.

**Step 3:** 1-9 rating is used to compare the barriers. This would be the Best-to-Others vector that results:

**Step 4**: 1-9 rating is used to compare which barrier is preferred over the worst.

**Step 5:** Determine the optimal weights: Consistency Ratio (CR) = $\boldsymbol{\xi}*$/consistency index(CI)

Thus, in this study the main barriers are selected and prioritized. Later, a sensitivity analysis strengthens the results.

### 3.1.2 Data Collection

The author visited some RMG factories in Dhaka, Chattogram and Gazipur and opinions from some university teachers, Bangladesh are taken. The imperatives are as given in the Table 1- Table 2:

Table 1. Expert Details

| Expert ID | Designation | Number of Experts | Experience |
|---|---|---|---|
| **E1** | Supply Chain Manager | 2 | 12 years |
| **E2** | IT Manager (RMG Factory) | 1 | 10 years |
| **E3** | Blockchain Consultant | 1 | 7 years |
| **E4** | University Researcher | 3 | 4 years |
| **E5** | Merchandiser (Buying House) | 1 | 8 years |
| **E6** | University Teacher | 2 | 8 years |

Table 2. Barriers to Blockchain Adoption in RMG Industry

| Barrier ID | Barrier Description | TOE Dimension |
|---|---|---|
| BD1 | Cost of implementing digital technologies | Technology |
| BD2 | Operating and maintenance costs | Technology |
| BD3 | Lack of internet infrastructure | Technology |
| BD4 | Technological immaturity | Technology |
| BD5 | Organizational inertia | Organization |
| BD6 | Lack of skilled human resources | Organization |
| BD7 | Lack of R&D capabilities | Organization |
| BD8 | Lack of government support | Environment |
| BD9 | Complex and fragmented FSC | Environment |
| BD10 | Inconsistent sustainability policies | Environment |

The BEST and the WORST Criteria are selected by the Experts.

Best (Most critical barrier) → BD1: Cost of implementing digital technologies

Worst (Least critical barrier) → BD5: Organizational inertia

### 3.1.3: Numerical Results

The first step was to identify the best and the worst alternatives, as shown in Table 3. The next step was to compare the best alternative with the others and the worst alternative with the others, as presented in Tables 4 to 9.

Table 3. Best and Worst alternatives selection

| Expert | Best (Most important) | Worst (Least important) |
|---|---|---|
| E1 | BD1 | BD5 |
| E2 | BD1 | BD10 |
| E3 | BD4 | BD5 |
| E4 | BD1 | BD4 |
| E5 | BD5 | BD7 |
| E6 | BD1 | BD7 |
| E7 | BD1 | BD5 |
| E8 | BD1 | BD5 |
| E9 | BD1 | BD8 |
| E10 | BD4 | BD5 |

Table 4. Compare the best to others
*(ColumnsBD1,BD2,BD3,BD4,BD5,BD6,BD7,BD8,BD9,BD10, scale 1–9 where 1 = equal, 9 = extremely more important than the other)*

| Expert | BD1 | BD2 | BD3 | BD4 | BD5 | BD6 | BD7 | BD8 | BD9 | BD10 |
|---|---|---|---|---|---|---|---|---|---|---|
| E1 | 1 | 4 | 6 | 8 | 9 | 5 | 6 | 4 | 6 | 7 |
| E2 | 5 | 4 | 4 | 5 | 8 | 8 | 6 | 3 | 6 | 2 |
| E3 | 2 | 7 | 6 | 9 | 8 | 8 | 7 | 8 | 5 | 5 |
| E4 | 6 | 6 | 4 | 3 | 9 | 8 | 6 | 7 | 7 | 5 |
| E5 | 7 | 8 | 8 | 8 | 9 | 8 | 7 | 8 | 7 | 8 |
| E6 | 4 | 7 | 8 | 7 | 6 | 6 | 5 | 6 | 7 | 6 |
| E7 | 2 | 6 | 8 | 7 | 9 | 6 | 5 | 8 | 7 | 5 |
| E8 | 6 | 7 | 7 | 8 | 8 | 8 | 6 | 7 | 5 | 7 |
| E9 | 2 | 6 | 7 | 8 | 9 | 4 | 7 | 3 | 5 | 7 |
| E10 | 3 | 7 | 6 | 9 | 7 | 5 | 8 | 6 | 7 | 6 |

Table 5. Compare the others to the worst
*(ColumnsBD1,BD2,BD3,BD4,BD5,BD6,BD7,BD8,BD9,BD10, scale 1–9 where 1 = equal, 9 = extremely more important than the other)*

| Expert | BD1 | BD2 | BD3 | BD4 | BD5 | BD6 | BD7 | BD8 | BD9 | BD10 |
|---|---|---|---|---|---|---|---|---|---|---|
| E1 | 9 | 4 | 6 | 8 | 1 | 5 | 6 | 4 | 6 | 7 |
| E2 | 9 | 4 | 4 | 5 | 3 | 5 | 6 | 3 | 6 | 2 |
| E3 | 8 | 7 | 6 | 9 | 4 | 8 | 7 | 8 | 5 | 5 |
| E4 | 9 | 6 | 4 | 3 | 5 | 6 | 6 | 7 | 7 | 5 |
| E5 | 7 | 8 | 8 | 8 | 9 | 8 | 7 | 8 | 7 | 8 |
| E6 | 9 | 7 | 8 | 7 | 6 | 6 | 5 | 6 | 7 | 6 |
| E7 | 9 | 6 | 8 | 7 | 4 | 6 | 5 | 8 | 7 | 5 |
| E8 | 9 | 7 | 7 | 8 | 4 | 8 | 6 | 7 | 5 | 7 |
| E9 | 8 | 6 | 7 | 8 | 5 | 4 | 7 | 3 | 5 | 7 |
| E10 | 9 | 7 | 6 | 9 | 2 | 5 | 8 | 6 | 7 | 6 |

Table 6. Final ranking of the imperatives:

| Rank | Barrier ID | Barrier Description | TOE Dimension | Optimal Weight ($w_j$*) | Percentage Weight |
|---|---|---|---|---|---|
| 1 | BD1 | Cost of implementing digital technologies | Technology | 0.2662 | 26.62% |
| 2 | BD4 | Technological immaturity | Technology | 0.1177 | 11.77% |
| 3 | BD10 | Inconsistent sustainability policies | Environment | 0.1109 | 11.09% |
| 4 | BD2 | Operating and maintenance costs | Technology | 0.0853 | 8.53% |
| 5 | BD8 | Lack of government support | Environment | 0.0853 | 8.53% |
| 6 | BD7 | Lack of R&D capabilities | Organization | 0.0785 | 7.85% |
| 7 | BD6 | Lack of skilled human resources | Organization | 0.0717 | 7.17% |
| 8 | BD9 | Complex and fragmented FSC | Environment | 0.0666 | 6.66% |
| 9 | BD3 | Lack of internet infrastructure | Technology | 0.0614 | 6.14% |
| 10 | BD5 | Organizational inertia | Organization | 0.0563 | 5.63% |

Now the table (Table-10) shows that the ten imperatives, “Barriers to Blockchain Adoption in Supply Chain Management in the RMG Sector of Bangladesh”,“ Cost of implementing digital technologies” got the highest importance. Besides the Organizational inertia got the lowest importance. So, for the betterment of RMG sector we must eye on cost of implementing digital technologies. National and International knowledge sharing and technology sharing collaboration can act as an effective role at RMG sector of Bangladesh.

## 3.2 Graph Theory Matrix Approach (GTMA)

Definition 1: It is a multi-criteria decision-making method that models interrelationships among a set of ( x ) criteria, X={1,2,……,x}, using a weighted directed graph. If criterion $i$ directly influences criterion $j$, the dominance strength is represented by the matrix element $a_{ij}\in\{1,2,\ldots,9\}$, $i \neq j$ and is referred to as a primary relationship.

Definition 2: An influence between criteria that arises through one or more intermediate criteria is termed a secondary relationship.

Definition 3:The GTMA matrix $A = [a_{ij}]_{x\times x}$ represents all direct interactions with $a_{ii} = 0$ indicating no self-influence.

**3.2.1:Steps of GTMA**

**Step 1**: We identified ten barriers to blockchain adoption and their drivers(already mentioned) in the RMG supply chain through literature review and expert survey.(Agrawal et al. 2016)

The drivers used in the GTMA matrices are Government Policy & Support (GPS), Access to Capital & Funding(ACF), ICT & Digital Infrastructure(IDI), Human Capital & Training (HCT), Organizational Readiness & Leadership(ORL), Industry Collaboration & Partnerships(ICP), Market Pressure & Buyer Demands(MPD), R&D & Innovation Ecosystem(RIE), Regulatory Standards & Clarity(RSC), Supply Chain Integration & Coordination(SCI).

**Step 2:** The relative importance among the drivers was determined, defined in Table-2. These pairwise comparison outcomes were used in the off-diagonal elements of the 10×10 Matrix.
**Step 3:** For each barrier, expert gives the influence level of all ten drivers using Table-3, thus we get ten influence scores per barrier. These influence scores were used as the diagonal values (Dij) of the matrix for each barrier.
**Step 4:** Using the off-diagonal (driver-importance) and diagonal (driver-influence) values, a 10×10 GTMA matrix was constructed separately for each of the ten barriers. This resulted in ten distinct attribute matrices, denoted as BD1 to BD10.
[A]=

$$\begin{bmatrix} & GPS & ACF & IDI & HCT & ORL & ICP & MPD & RIE & RSC & SCL \\ GPS & D_1 & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} & a_{17} & a_{18} & a_{19} & a_{110} \\ ACF & a_{21} & D_2 & a_{23} & a_{24} & a_{25} & a_{26} & a_{27} & a_{28} & a_{29} & a_{210} \\ IDI & a_{31} & a_{32} & D_3 & a_{34} & a_{35} & a_{36} & a_{37} & a_{38} & a_{39} & a_{310} \\ HCT & a_{41} & a_{42} & a_{43} & D_4 & a_{45} & a_{46} & a_{47} & a_{48} & a_{49} & a_{410} \\ ORL & a_{51} & a_{52} & a_{53} & a_{54} & D_5 & a_{56} & a_{57} & a_{58} & a_{59} & a_{510} \\ ICP & a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & D_6 & a_{67} & a_{68} & a_{69} & a_{610} \\ MPD & a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & D_7 & a_{78} & a_{79} & a_{710} \\ RIE & a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & D_8 & a_{89} & a_{810} \\ RSC & a_{91} & a_{92} & a_{93} & a_{94} & a_{95} & a_{96} & a_{97} & a_{98} & D_9 & a_{910} \\ SCI & a_{101} & a_{102} & a_{103} & a_{104} & a_{105} & a_{106} & a_{107} & a_{108} & a_{109} & D_{10} \end{bmatrix}$$

**Step 5:** The permanent of each 10×10 matrix was computed to obtain a unique structural index for every barrier which were then ranked in descending order. The barrier with the highest permanent is the most influential (Ferdous 2024). For an $\boldsymbol{n} \times \boldsymbol{n}$matrix $\boldsymbol{A} = [\boldsymbol{a_{ij}}]$, the permanent is defined as:

$$\mathrm{Perm}(\boldsymbol{A}) = \sum_{\sigma \in S_n} \prod_{i=1}^{n} \boldsymbol{a}_{i,\sigma(i)}$$

This definition is evaluated using the Jurkat–Ryser formulation to reduce computational complexity. In this study, for each 10×10 GTMA matrix, the permanent represents the cumulative influence of all drivers associated with each barrier. A higher permanent indicates a barrier with greater systemic impact and priority in blockchain adoption.

Table 7. Relative importance of the drivers

| Description | aij | 1-aij |
|---|---|---|
| Two drivers are equally important | 0.5 | 0.5 |
| One driver(i) is slightly more important over the other (j) | 0.6 | 0.4 |
| One driver(i) is strongly more important over the other (j) | 0.7 | 0.3 |
| One driver (i) is very strongly important over the other (j) | 0.8 | 0.2 |
| One driver (i) is extremely important over the other (j) | 0.9 | 0.1 |
| One driver (i) is exceptionally more important over the other (j) | 1 | 0 |

Table 8. Importance of drivers for each barrier

| Qualitative measure of attributes | Assigned Value of Dij |
|---|---|
| Exceptionally low | 0.0 |
| Extremely low | 0.1 |
| Very low | 0.2 |
| Low | 0.3 |
| Below average | 0.4 |
| Average | 0.5 |
| Above average | 0.6 |
| High | 0.7 |
| Very high | 0.8 |
| Extremely high | 0.9 |
| Exceptionally high | 1.0 |

Table 9. Diagonal element values

| **Driver ↓ / Barrier →** | **BD1** | **BD2** | **BD3** | **BD4** | **BD5** | **BD6** | **BD7** | **BD8** | **BD9** | **BD10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **GPS** | 0.7 | 0.5 | 0.8 | 0.5 | 0.3 | 0.6 | 0.5 | 0.9 | 0.4 | 0.8 |
| **ACF** | 0.9 | 0.8 | 0.6 | 0.5 | 0.4 | 0.5 | 0.6 | 0.5 | 0.4 | 0.4 |
| **IDI** | 0.6 | 0.7 | 0.9 | 0.7 | 0.3 | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 |
| **HCT** | 0.4 | 0.6 | 0.4 | 0.5 | 0.4 | 0.9 | 0.6 | 0.4 | 0.4 | 0.4 |
| **ORL** | 0.5 | 0.4 | 0.3 | 0.4 | 0.9 | 0.5 | 0.4 | 0.3 | 0.4 | 0.3 |
| **ICP** | 0.7 | 0.5 | 0.5 | 0.7 | 0.6 | 0.6 | 0.7 | 0.4 | 0.8 | 0.5 |
| **MPD** | 0.6 | 0.4 | 0.4 | 0.5 | 0.8 | 0.5 | 0.4 | 0.6 | 0.6 | 0.7 |
| **RIE** | 0.5 | 0.4 | 0.4 | 0.8 | 0.4 | 0.5 | 0.9 | 0.3 | 0.4 | 0.4 |
| **RSC** | 0.5 | 0.4 | 0.5 | 0.4 | 0.3 | 0.4 | 0.5 | 0.9 | 0.5 | 0.9 |
| **SCI** | 0.6 | 0.5 | 0.8 | 0.6 | 0.4 | 0.5 | 0.5 | 0.4 | 0.9 | 0.6 |

$$[B]=\begin{bmatrix} & GPS & ACF & IDI & HCT & ORL & ICP & MPD & RIE & RSC & SCL \\ GPS & D1 & 0.8 & 0.7 & 0.7 & 0.8 & 0.9 & 0.6 & 0.9 & 0.5 & 0.7 \\ ACF & 0.2 & D2 & 0.7 & 0.7 & 0.8 & 0.5 & 0.5 & 0.5 & 0.6 & 0.7 \\ IDI & 0.3 & 0.3 & D3 & 0.8 & 0.8 & 0.7 & 0.6 & 0.6 & 0.6 & 0.6 \\ HCT & 0.3 & 0.3 & 0.2 & D4 & 0.5 & 0.6 & 0.8 & 0.7 & 0.6 & 0.8 \\ ORL & 0.2 & 0.2 & 0.2 & 0.5 & D5 & 0.6 & 0.6 & 0.8 & 0.5 & 0.7 \\ ICP & 0.1 & 0.5 & 0.3 & 0.4 & 0.4 & D6 & 0.5 & 0.6 & 0.5 & 0.6 \\ MPD & 0.4 & 0.5 & 0.4 & 0.2 & 0.4 & 0.5 & D7 & 0.8 & 0.7 & 0.6 \\ RIE & 0.1 & 0.5 & 0.4 & 0.3 & 0.2 & 0.4 & 0.2 & D8 & 0.8 & 0.8 \\ RSC & 0.5 & 0.4 & 0.4 & 0.4 & 0.5 & 0.5 & 0.3 & 0.2 & D9 & 0.8 \\ SCI & 0.3 & 0.3 & 0.4 & 0.2 & 0.3 & 0.4 & 0.4 & 0.2 & 0.2 & D10 \end{bmatrix}$$

The permanent function value, decision index values for ten barriers were determined by using computer program.
For BD1:

$$\begin{bmatrix} & GPS & ACF & IDI & HCT & ORL & ICP & MPD & RIE & RSC & SCL \\ GPS & 0.7 & 0.8 & 0.7 & 0.7 & 0.8 & 0.9 & 0.6 & 0.9 & 0.5 & 0.7 \\ ACF & 0.2 & 0.9 & 0.7 & 0.7 & 0.8 & 0.5 & 0.5 & 0.5 & 0.6 & 0.7 \\ IDI & 0.3 & 0.3 & 0.6 & 0.8 & 0.8 & 0.7 & 0.6 & 0.6 & 0.6 & 0.6 \\ HCT & 0.3 & 0.3 & 0.2 & 0.4 & 0.5 & 0.6 & 0.8 & 0.7 & 0.6 & 0.8 \\ ORL & 0.2 & 0.2 & 0.2 & 0.5 & 0.5 & 0.6 & 0.6 & 0.8 & 0.5 & 0.7 \\ ICP & 0.1 & 0.5 & 0.3 & 0.4 & 0.4 & 0.7 & 0.5 & 0.6 & 0.5 & 0.6 \\ MPD & 0.4 & 0.5 & 0.4 & 0.2 & 0.4 & 0.5 & 0.6 & 0.8 & 0.7 & 0.6 \\ RIE & 0.1 & 0.5 & 0.4 & 0.3 & 0.2 & 0.4 & 0.2 & 0.5 & 0.8 & 0.8 \\ RSC & 0.5 & 0.4 & 0.4 & 0.4 & 0.5 & 0.5 & 0.3 & 0.2 & 0.5 & 0.8 \\ SCI & 0.3 & 0.3 & 0.4 & 0.2 & 0.3 & 0.4 & 0.4 & 0.2 & 0.2 & 0.6 \end{bmatrix}$$

**Permanent of [BD1]:** 2937.5336.
Similarly, the rest of the permanent values are: Permanent of [BD2]: 2483.4872, Permanent of [BD3]: 2704.7036, Permanent of [BD4]: 2708.8469, Permanent of [BD5]: 2269.6289, Permanent of [BD6]: 2661.3803, Permanent of [BD7]: 2704.7822, Permanent of [BD8]: 2466.1457, Permanent of [BD9]: 2526.6368, Permanent of [BD10]: 2573.6997. These values are listed in descending order as follows:

Table 10. Barriers Ranking

| **Rank** | **Barrier ID** | **Permanent Value** |
|---|---|---|
| **1** | BD1 | 2937.5336 |
| **2** | BD4 | 2708.8469 |
| **3** | BD7 | 2704.7822 |
| **4** | BD3 | 2704.7036 |
| **5** | BD6 | 2661.3803 |
| **6** | BD10 | 2573.6997 |
| **7** | BD9 | 2526.6368 |
| **8** | BD2 | 2483.4872 |
| **9** | BD8 | 2466.1457 |
| **10** | BD5 | 2269.6289 |

### 3.2.2 The result of GTMA

From the values of permanent matrices we found that BD1 (high cost of digital technologies) is the biggest challenge, as most factories cannot afford blockchain infrastructure or IoT tools. BD4 (technological immaturity) and BD3 (poor internet infrastructure) is on the second position problem because many factories still operate with traditional systems, unreliable cracked connectivity, and limited cybersecurity.

On the organizational side, BD7 (lack of R&D capability) and BD6 (shortage of skilled human resources) we interpret that most firms simply do not have the people or expertise needed to explore or implement blockchain.

Environmental barriers like BD10 (inconsistent sustainability policies) and BD9 (complex, fragmented supply chains) create minor issue in this advanced blockchain adoption and make full traceability difficult. BD8 (limited government support) and BD5 (organizational inertia) have a smaller overall impact.

So, blockchain adoption in Bangladesh's RMG sector is mainly held back by high costs, weak technological readiness, and a shortage of capable people which shows a big impact of technological framework barrier on blockchain implementation. Policy gaps and supply-chain complexity also have impact but we can consider it as minor impact. Furthermore, the industry needs investment, skill-building, and clearer policies to create a digital and innovation-friendly environment to keep Bangladesh's RMG sector booming worldwide.

## 4. Discussion

This study aimed to explore the main challenges regarding the adoption of blockchain technology (BT) in the supply chain management of Bangladesh's RMG sector by using the TOE framework along with the BWM and GTMA methods. The findings reveal that technological issues such as poor digital infrastructure, a shortage of skilled technical employees and the difficulty of linking blockchain with existing systems are the most significant problems. Similar patterns have been observed in other developing countries where gaps in IT readiness and the complexity of new systems often slow down the digital transformation initiatives. Organizational barriers also play an important role here. When the employees have limited awareness, resist change or when top management shows little commitment, it becomes quite hard for industries to feel confident or motivated to adopt new technologies. Alongside this, environmental factors like unclear regulations and a lack of government support highlight the need for stronger institutional backing if blockchain is to be used for greater worth. The GTMA results further show that these barriers are closely connected. Technological weaknesses tend to intensify both organizational and environmental challenges. This means that focusing on isolated solutions like staff training or regulatory reform may not be enough. These actions need to be paired with improvements in infrastructure and system integration capacity. Overall, the results show that bringing blockchain into the RMG sector is much more than about upgrading technology. Real advancement needs tackling multiple challenges together. By enhancing accountability, reliability and legal sourcing, the sector can better meet global standards and develop crucial confidence across the supply chain.

### 4.1 Limitations

This study has several limitations that should be acknowledged. First, the expert sample used for the BWM and GTMA analyses was relatively small which might not accurately represent the wide range of all RMG stakeholders that may affect the generalizability of the findings. Second, the analysis reflects current technological and regulatory conditions which can change over time and affect the ranking of barriers over time. Finally, because the study focuses only on the Bangladesh RMG industry, the results may not apply to other industries or countries though they can offer useful insights for similar emerging-market contexts.

### 4.2 Future Scope

Our findings point to several crucial areas for future research concerning blockchain adoption in the Ready-Made Garment (RMG) supply chain. One key direction is to broaden the scope of studies to include the smaller and more geographically dispersed firms. Digital transformation surveys tend to miss micro and small suppliers (Habib et al. 2025). Case studies and pilot projects that follow these firms over longer periods would help us understand how their organizational setup and market conditions change. Beyond just recording these changes, researchers should focus on what interventions actually help—whether it's specialized training, financial assistance, or industry-wide standards. Understanding what actually lowers the barriers matters more than theoretical speculation.

Secondly, the theoretical frameworks used to study adoption should be refined. For instance, incorporating the concept of Task–Technology Fit (TTF) into the widely used Technology–Organization–Environment (TOE) framework could provide a much better assessment of whether blockchain truly aligns with the specific needs of its users (Wong et al. 2024). Combining TOE with TTF would give us a better way to assess whether blockchain actually meshes with how people work and whether employees have the right skill sets. It's worth comparing Bangladesh with neighbors like India or Vietnam too—that way we can see which barriers stem from local issues versus problems that hit the whole garment industry. We also need real evidence on how policy changes and infrastructure work. For example, studying initiatives like mandatory e-invoicing or SME grants could reveal if they truly accelerate adoption or just create compliance burdens. A comprehensive strategy is key here: it must combine detailed qualitative work with advanced quantitative modeling and real-world experiments on integrating blockchain into Bangladesh's RMG supply chains to deliver truly actionable insights for leaders and policymakers(Wong et al. 2024) (Habib et al. 2025).

## 5. Conclusion

In this study, BWM and GTMA have applied to find the most influential barrier to blockchain adoption in Supply Chain Management using TOE framework in the RMG Sector of Bangladesh. Both methods have been applied to ensure the result validation. For the BWM, we collected expert opinion and used the values for further calculation. Thus, we get a ranking of barriers using BWM. Then, we have used GTMA. This approach required drivers that influence all the barriers. We took these drivers from the experts' survey and literature review. Which was later used in the matrix form. The decsending order of permanents of these matrices gave a ranking for the barriers.

Analyzing both the rankings, we can say that the technological barriers are the most influential barriers to adopting blockchain in SCM. This approach can systematically improve supply chain transparency, ensure ethical compliance, and boost the global competitiveness and sustainability of Bangladesh's RMG sector. Therefore, the research contributes by integrating the BWM and GTMA, offering a structured framework for understanding and overcoming challenges in blockchain adoption.

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## Biographies

**Atika Ashraf Akhi** is currently pursuing her bachelor's degree in the Department of Industrial & Production Engineering at Rajshahi University of Engineering & Technology (RUET).

**Razoan Islam Zihad** is presently enrolled in the Department of Industrial and Production Engineering at Jashore University of Science and Technology (JUST) to complete his undergraduate studies in Industrial and Production Engineering. He has already published a paper about E-waste Management for sustainability and has presented at the IEOM International Conference. His research area of interest includes E-Waste management, blockchain technology, supply chain management, and operations research.

**Khaleda Yeasmin Mim** is a BSc. student studying at the Department of Electrical and Electronic Engineering (EEE) at Jashore University of Science and Technology (JUST). She has strong interests in biomedical science, supply chain management, plasma, and materials science.

**Md. Nazmus Sakib** is currently pursuing a Bachelor of Science degree in Computer Science and Engineering (CSE) at Bangladesh University of Engineering and Technology (BUET). He has authored a short paper titled "SuperArchitecture: A New Approach for Reconnaissance over Data Centers Considering Architectural Alternatives," highlighting his focus on advancing knowledge in data center reconnaissance methodologies and architectural innovation.

**Shoyeb Muhammad** is currently pursuing his master's degree at Gunma University, Japan, as a MEXT Scholar. He is a Lecturer of Industrial and Production Engineering (IPE) at Jashore University of Science and Technology (JUST). He has obtained his Bachelor of Science in Industrial and Production Engineering from Jashore University of Science and Technology.