Proceedings of the Fourth Australian International Conference on Industrial Engineering and Operations Management, Melbourne, Australia, November 25-27, 2025

Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AU04.20250075
Published: November 25, 2025

Blockchain Applications in the Automotive Industry: Opportunities, Challenges and Pathways to Industry 4.0

Fattah bin Siddique, Abday Mohaimin, Kazi Md. Tanvir Anzum and Syed Rafidul Islam
Department of Industrial Engineering and Management
Khulna University of Engineering & Technology, Khulna-9203, Bangladesh
fattahbinsiddique@gmail.com, abday.raheel2002@gmail.com, tanvir@iem.kuet.ac.bd, islamrafidul6@gmail.com

Abir Ahsan
Department of Materials Science and Engineering
Khulna University of Engineering & Technology, Khulna-9203, Bangladesh
abirahsan9953@gmail.com

Abstract

In the ever-evolving landscape of automobile industry, technological advancements continue to drive innovation and among the array of disruptive technologies blockchain technology stands out as a groundbreaking solution with the potential to reshape the core pillars of automobile industry. The automobile sector finds itself on the precipice of a profound paradigm shift as blockchain technology promises to revolutionize the way automobile industry functions. Blockchain is decentralized and cryptographic in nature which makes it by default secure while enhancing data anonymity, traceability, transparency, and authentication, as well as providing long-term sustainability and a higher operational efficiency to the whole automobile industry. With more market integration and the capacity to offer individualized services depending on client needs, such as automated pilot, car sharing, and intelligent network vehicles, the automobile industry of the future will differ from that of the present. As blockchain works through decentralization and digitization, it is crucial that records should be kept in order to prepare for the impending industry transition. Automotive industry consists not only of vehicle manufacturers (OEMs) but also the suppliers (components), dealers, service and repair, automotive technology companies (software, CS unit). So, to ensure transparency and other objectives of the supply chain and overall operation blockchain is highly advisable for the automotive industry.

Keywords

Blockchain Technology; Automotive Industry; Supply Chain Transparency; Vehicle Lifecycle Management; Smart Contracts; Industry 4.0; Digital Transformation

1. Introduction

Blockchain technology is changing the face of numerous industries, and the automobile industry is one of them. It is at the core of the reimagining of traditional processes with better data security, improved transparency, and streamlined operations. Auto players are increasingly adopting blockchain for use cases such as secure data transfer, transparent supply chains, and emerging mobility solutions (Zhao et al. 2016). The major sections of automobiles where blockchain is creating revolutionary changes are given below:

1.1 Vehicle Lifecycle Documentation:

The first and one of the most important applications of blockchain technology in the automobile industry is managing the whole lifecycle of a vehicle. Blockchain is such a technology that can contain unchangeable timestamped

information from the manufacturing process to the resale stage. Blockchain provides users with a correct and tamper-proof electronic record of the complete lifecycle of a vehicle from manufacture to ownership changes, mileage, servicing, accident history, warranty verification and insurance claims processing (Fraga-Lamas et al. 2019). This builds more assurance on resale and does away with common issues like odometer manipulation and unauthorized resale of hijacked automobiles (Mohanta et al. 2019). At the same time blockchain enables all stakeholders—manufacturers, sellers, and buyers—to share one, open source of authenticated information.

1.2 Supply Chain Visibility and Authentication:

Nowadays, in the automobile manufacturing industry, supply chain transparency is a major concern. Different vehicles are made up of different components from different geography and right now blockchain is the most upgraded solution to verify the source of every component, movement and authenticity. Blockchain can track raw materials and components in real time throughout the supply chain (Ada et al. 2021). Blockchain helps manufacturers with verifying the provenance of parts, minimizing the supply of fake goods, and ensuring ethical sourcing, especially sensitive materials like cobalt contained in electric vehicle batteries (Habibullah et al. 2024). Blockchain also makes compliance with regulation and environmental standards easier.

1.3 Data Integrity for Autonomous Vehicles:

The requirement for autonomous and connected vehicles is secure transfer of voluminous data. Blockchain makes such type of data exchanges between vehicles, infrastructure, and central systems immutable and decentralized (Sharma et al. 2018). This can lead to efficient and safer operations, trustworthy vehicle-to-vehicle communication and real-time traffic information (Mikavica et al. 2021).

1.4 Behavior-Based Insurance Solutions:

According to the traditional way, insurance and motor vehicles billing processes simply depend on the price of vehicle and its age. Driving behavior and maintenance are less important for insurance here. nowadays Blockchain allows usage-based insurance to be created by securely recording telematics data such as speed, distance traveled, and driving habits (Singh et al. 2019). The authenticated data can then be used by insurers to offer individualized premiums. Since the data is recorded on a decentralized network, it becomes tamper-proof and unchanging (Chen et al. 2022).

1.5 Secure Over-the-Air (OTA) Software Updates:

Modern cars are routinely updated with software remotely. Blockchain can be used to verify such updates and track the history of versions of the software, so that only verified and secure updates are deployed (Mohammad et al, 2022). This reduces the likelihood of cyber-attacks and unauthorized changes to critical car systems.

1.6 Smart Mobility and Automated Contracts:

Smart contracts can be utilised in automation of batteries such as payment, rentals and returns in shared mobility and car rental activities. Smart contracts are automated contracts which are automatically executed to term when certain conditions are met and thus minimize the role of the intermediaries and the level of trust among the users. Repayment, as an example, could only be automatic on the condition that a rental vehicle is returned in good conditions (Figure 1).

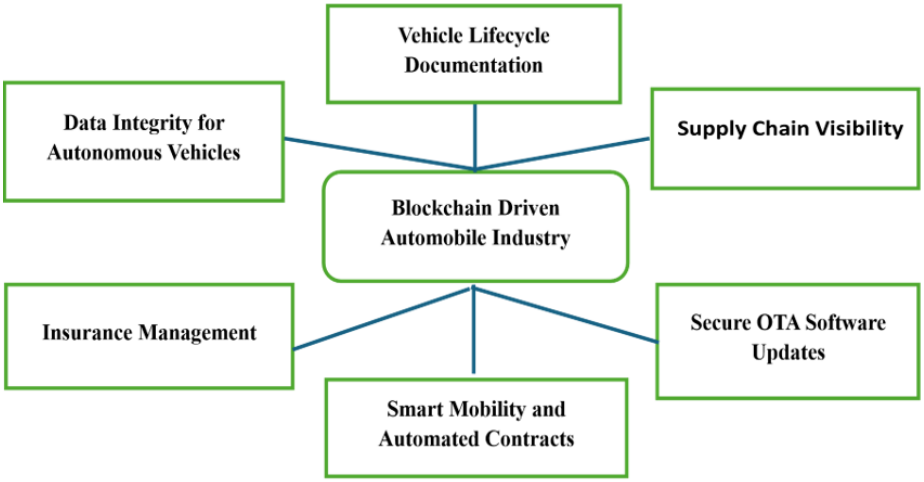

Figure 1. Role of blockchain technology

2. Conceptual Framework: Linking Blockchain to Industry 4.0

Industry 4.0 transition is marked by a number of principles or pillars, such as interoperability, decentralization, real-time capability, and service orientation. The nature of blockchain technology provides an underlying layer, which can be used to support these pillars in the automotive sector.

- Decentralization: Industry 4.0 advocates decentralization of decisions, under which cyber-physical systems can be autonomous. The blockchain distributed ledger technology (DLT) is decentralized and does not have points of failures and control. This comes in line with the fact that powerful and autonomous chains of manufacturers, suppliers, vehicles, and infrastructure are required.
- Interoperability: The pillar is connected with the reality that various systems (humans, machines, sensors) are able to interact and be connected. Blockchain may not guarantee any type of interoperability, but it may provide a shared and trusted data foundation that is able to be read and written by dissimilar systems with standardized protocols, defining a shared source of truth without necessarily interconnecting separate systems with one another.
- Transparency & Traceability: Industry 4.0 operates on the real-time functionality which is founded on dependable, current data. Blockchain provides an accurate and immutable record of operations and transactions. This is also done to enable all parties that may be interested in the automotive supply chain, say, to track the provenance of component between raw material and final assembly in real-time.
- Smart Contracts: Automation Industry 4.0 sees the development of new and data-driven services. The smart contracts of blockchain, which are self-executable contracts, with predefined logic can be used to automate any complex business logic and processes, such as using-based insurance premium-calculation or creating payments that are automatic when a vehicle is returned in a sharing-economy model (Figure 2).

This framework proves that blockchain is not to be considered an isolated solution but rather as a hypothetical architectural element that strengthens the technological and philosophical changes that Industry 4.0 is based on.

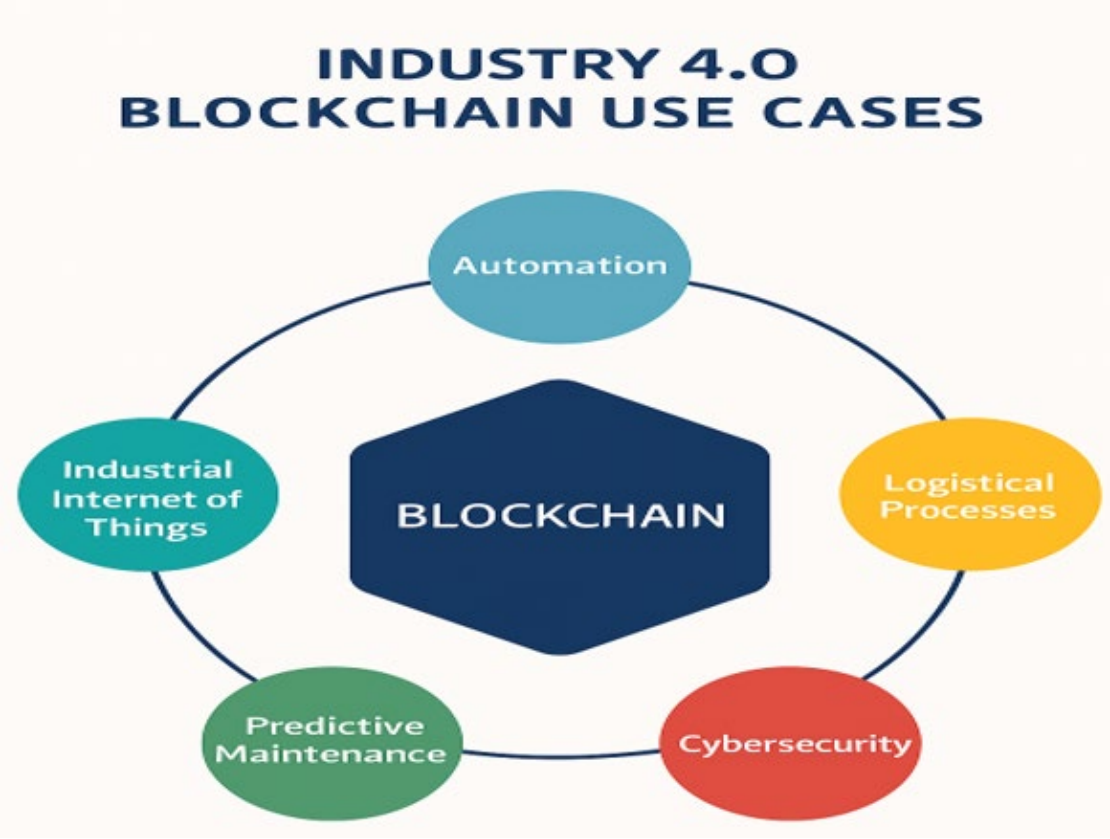

Figure 2. Conceptual diagram of blockchain uses in Industry 4.0

3. The application foundation of block chain in automotive industry

The application foundations of blockchain in automotive industry are mentioned below:

3.1. Changes in automobile consumption behavior

In the automobile industry, consumer behavior is evolving, and on-demand services and electric transportation are expanding. In the meantime, the transformation is accelerated by people's increased willingness to utilize technology and share data. Carpooling and automobile sharing are growing in popularity among young urban customers. As consumers look for more economical and ecologically responsible modes of transportation, the demand for electric vehicles is also rising (Zhao et al, 2018).

3.2. Automotive data requirements

Businesses will be motivated to provide new transportation and logistical services, creative products, and manufacturing technologies as a result of technology improvements and growing need for data consumption. However, a significant amount of data and client information has yet to be used. Customers can gain insight by analyzing customer data for commercial purposes. Analysis of vehicle use and expertise can lead to new business opportunities. (Zhao et al, 2018).

3.3. Vehicle utilization

Other inefficient aspects in the automobile sector include the high cost of holdings and the small quantity of vehicles in use. Even if their vehicles are parked and not in use 95% of the time, owners must still pay fixed expenses such as coverage, revenues, repairs, and parking fees. As a result, every sector, including manufacturers, distributors, retailers, financial institutions, and users, has block chain opportunities (Zhao et al, 2018).

3.4. Government regulation

Government rules and the fresh competitive landscape impose significant constraints on banking operations and information technology systems. Peer-to-peer funding and open banking have made conventional automakers more competitive.

4. Application of block chain in automobile industry

Based with the category, the function of block chain is primarily summarized in three aspects: (1) financing, payment, and insurance. (2) Vehicle management and incentives for innovation (3) evaluation and process improvement.

4.1 Auto finance, insurance and payment:

There are several block chain applications across the entire value chain for banking, payment, and insurance services. The case study for this application direction is as follows:

1. Insurance Contract: Companies like Gem and Toyota use driving data to create tailored insurance plans. Claims are processed via smart contracts, which automatically initiate payouts (Zhao et al, 2018).

2. Electric Car Payment: Peer-to-peer energy transactions are made possible by RWE's Bio Charge. With the help of blockchain technology, EV owners can safely pay for charging or sell extra electricity back to the grid (Zhao et al, 2018).

3. Internet Services: Users can use ZF and UBS's Care Wallet to pay for parking, entertainment, and tolls without using cash. The transactions are handled smoothly by predefined blockchain contracts (Zhao et al, 2018).

4. Car Rental and Finance: Blockchain technology is being used by Daimler and Barden Württemberg State Bank to handle lease agreements, securely connect rental stakeholders, and automate payments following vehicle return (Zhao et al, 2018).

4.2. Validation and process improvement in vehicle supply chain

Many chain application cases are used to validate and improve processes along the value chain. It is primarily employed in the following directions:

1. Accurate Recall Deloitte Tracechain, which is based on a blockchain system, allows automakers to discover automobiles with problematic parts and accurately publish recalls or service alerts. Furthermore, the application may monitor the status of recalls, including sending the distributor for repairs and filing regulatory reports to the government following completion of reparations (Zhao et al, 2018).
2. Origin traceability and validation: By tracing the origin and manufacture dates of spare parts, ArtTrackti helps customers and service centers establish their legitimacy (Zhao et al, 2018)
3. Request Information from Vendors SmartID validates supplier credentials and manages digital contracts and processes by leveraging blockchain-based digital identities (Zhao et al, 2018)
4. Interconnected Supply Chain: By providing tangible objects digital identities, Tracechain allows for easy tracking of orders, deliveries, and payments (Zhao et al. 2016).

4.3. Vehicle management

Many current reports on vehicle management and incentive programs warrant examination. The cases that support these procedures are as follows:

1. On-demand and carpool travel services: Toyota's blockchain technology enables peer-to-peer car sharing, access control, and trip payments, allowing owners to monetize their vehicles (Zhao et al, 2018).
2. Customer incentives: Loyyal's platform uses smart contracts to permit fast point exchanges, reducing delays and improving system interoperability (Zhao et al, 2018)
3. Milestone Fraud: In order to avoid fraud and ensure data quality, Bosch's IoT Lab captures mileage data from onboard devices using blockchain technology (Zhao et al, 2018)
4. Expanding Vehicle Accounts: Car Vertical gathers and validates vehicle history from various sources, enabling safe data exchange between third parties and manufacturers (Zhao et al. 2016).

5. Analysis of blockchain in automotive industry

The automobile industry is changing because blockchain is bringing transparency, efficiency, and automation in the financial services, supply chain operations, and vehicle management. Broadly, the applications of it can be divided into three categories: finance, payment and insurance; validation and process improvement within the supply chain; and vehicle management with customer incentives.

Blockchain allows secure and automatic transactions in the financial and insurance industry. There are already companies such as Toyota and Gem that use driving data to create customized insurance policies, and smart contracts automatically process claims, eliminating fraud and administrative delays. Equally, blockchain facilitates peer-to-peer electricity trading in the electric vehicle (EV) infrastructure, such as in the Bio Charge project by RWE, where local EV owners can safely pay to charge their vehicles or to sell their spare electricity to the grid. In addition, apps like ZF and the Care Wallet of UBS offer cashless parking, toll and entertainment payments, all of which are processed through blockchain contracts. In the area of leasing and rentals, Daimler and other companies are using blockchain to implement contract administration and automate payment processes and in the process enhance trust and efficiency in the relationship between the bank, the rental companies and the consumers.

Blockchain offers immense advantages in regards to supply chain management, whereby traceability and the validation at all the production and distribution processes are ensured. As an example, Tracechain by Deloitte enables automakers to detect malfunctioning parts and make accurate recalls as well as inform regulators automatically. Another similarity is that blockchain assists in certifying authenticity of the spare parts as witnessed in ArtTrackt that avoids the entry of imitated products in the market. Another related application is supplier credibility, such as SmartID, which has a blockchain-based identity to ensure vendors and contract management security. Assigning physical goods with digital identities, blockchain makes order and delivery tracking and payment across the supply chain easier and more reliable and compliant. Those strengths are reflected in industry cases - the XCEED platform by Renault helps to track compliance in supply chains, Circulor and Volvo rely on blockchain to guarantee the ethical origin of cobalt in EV batteries, and ARXUM offers tracking of manufacturing.

Blockchain is also of great benefit to vehicle management and incentives to the customers. An example is Toyota, which has launched a car-sharing service based on blockchain that allows owners to gain income by idly cars by sharing them with peers and securely paying counterparts to cover the trip. The customer loyalty programs are also augmented by services such as Loyyal where smart contracts are used to offer immediate point transactions and without delays in the systems. The other impact area is fraud prevention since Bosch IoT Lab tracks mileage data on the blockchain to avoid any odometer tampering, ensuring the safety of buyers and sellers in the second-hand car market. Also, CarVertical uses blockchain to obtain and verify the vehicle history across various sources, providing transparency and instilling confidence in used car purchases. Experimental activities also contribute to the developments: MG Motor in India has unveiled a blockchain-based Digital Vehicle Passport, Volkswagen in collaboration with IOTA is securing over-the-air (OTA) software updates, IBM is developing the usage of blockchains to log sensor data on autonomous vehicles, and BSEtec is developing blockchain solutions to EV charging infrastructure and vehicle identity management.

Altogether, blockchain usage in the car sector expands beyond the financial transactions and turns into the necessary instrument of trust, transparency, and innovation. Through fraud reduction and better regulatory compliance, along with opening up new mobility services like EV energy trading and peer-to-peer cars sharing, blockchain establishes itself as a pillar of the digital transformation of the industry. The first movers will have a huge benefit in terms of reduced costs of operation, enhanced customer confidence and more innovative business models that promote efficiency and user experience

6. Open challenges

Aside from the security benefits of blockchain, there are some drawbacks to its use in the automotive business.

6.1 Scalability

Blockchain requires every transaction and newly formed block to be shared across all participating nodes. As the number of nodes grows, (especially with the proliferation of smart vehicles) it leads to significant transaction overhead. Moreover, the limited bandwidth of these vehicles makes it difficult to handle the constant data broadcasting, resulting in scalability bottlenecks.

6.2 Computational Power

Complex algorithms that require a significant amount of processing power are required to maintain the integrity of the blockchain. The majority of smart automotive devices, however, have limited resources, which causes a discrepancy between the in-vehicle systems' capabilities and the blockchain's computational demands (Karthiga et al. 2021).

6.3 Latency

In blockchain systems, transaction validation can take a long time. For example, Bitcoin can take up to 30 minutes to validate a transaction. For smart cars operating in close proximity, where real-time communication is essential for safety and coordination, such delays are impractical(Karthiga et al. 2021).

6.4 Throughput

The performance of a blockchain is typically measured using the throughput of the blockchain, which is often measured as the number of transactions that blockchain can process in a given time frame (i.e. per second). Transaction volumes are significantly high in the environment of smart vehicle ecosystems. The subsequent increase in activity is a barrier to the mining process and as a consequence, reduces the efficiency and throughput of the entire system (Karthiga et al. 2021).

7. Conclusion

Blockchain technology is not just another conceptual term, but rather a powerful tool that can help to reduce some of the most urgent issues in the automotive industry, both currently and in the future. However, the level of security a certain blockchain implementation will provide depends upon its architectural design and its operational implementation. The primary obstacles include scalability problems, lack of interoperability between different blockchain solutions, regulatory uncertainty, and the necessity to collaborate with an industry as a whole. The implementation of blockchain, in its turn, should not be viewed as a choice, but rather as a compulsion owing to the growing number of applications in real life. The ability of blockchain technology to transform the automotive industry cannot be disputed.

References

Ada, N., Ethirajan, M., Kumar, A., V. K. E. K., Nadeem, S. P., Kazancoglu, Y. and Kandasamy, J., Blockchain technology for enhancing traceability and efficiency in automobile supply chain—A case study, Sustainability, vol. 13, no. 24, p. 13667, 2021.

Chen, C.-L., Zhu, Z.-P., Zhou, M., Tsaur, W.-J., Wu, C.-M. and Sun, H., A secure and traceable vehicles and parts system based on blockchain and smart contract, Sensors, vol. 22, no. 18, p. 6754, 2022.

Fraga-Lamas, P. and Fernandez-Carames, T. M., A review on blockchain technologies for an advanced and cyber-resilient automotive industry, IEEE Access, vol. 7, pp. 17578–17598, 2019.

Habibullah, S. M., Sikder, M. A., Tanha, N. I. and Sah, B. P., A review of blockchain technology's impact on modern supply chain management in the automotive industry, Global Mainstream Journal, vol. 3, no. 3, pp. 13–27, 2024.

Karthiga, M., Nandhini, S. S., Tharsanee, R. M., Nivaashini, M. and Soundariya, R. S., Blockchain for automotive security and privacy with related use cases, in Agrawal, R. and Gupta, N. (Eds.), Transforming Cybersecurity Solutions using Blockchain, pp. 185–214, Springer, Singapore, 2021.

Mikavica, B. and Kostić-Ljubisavljević, A., Blockchain-based solutions for security, privacy, and trust management in vehicular networks: A survey, The Journal of Supercomputing, vol. 77, no. 9, pp. 9520–9575, 2021.

Mohammad, A., Vargas, S. and Čermák, P., Using blockchain for data collection in the automotive industry sector: A literature review, Journal of Cybersecurity and Privacy, vol. 2, no. 2, pp. 257–275, 2022.

Mohanta, B. K., Jena, D., Panda, S. S. and Sobhanayak, S., Blockchain technology: A survey on applications and security privacy challenges, Internet of Things, vol. 8, p. 100107, 2019.

Sharma, P. K. and Park, J. H., Blockchain based hybrid network architecture for the smart city, Future Generation Computer Systems, vol. 86, pp. 650–655, 2018.

Singh, P. K., Singh, R., Muchahary, G., Lahon, M. and Nandi, S., A blockchain-based approach for usage based insurance and incentive in ITS, Proceedings of TENCON 2019 – IEEE Region 10 Conference (TENCON), pp. 1202–1207, Kochi, India, Oct. 17–20, 2019.

Zhao, D., Jia, G., Ren, H., Chen, C., Yu, R., Ge, P. and Liu, S., Research on the application of blockchain in automobile industry, IOP Conference Series: Materials Science and Engineering, vol. 452, p. 032076, 2018.

Zhao, J. L., Fan, S. and Yan, J., Overview of business innovations and research opportunities in blockchain and introduction to the special issue, Financial Innovation, vol. 2, no. 1, p. 28, 2016.

Biographies

Fattah bin Siddique is pursuing B.Sc. Engineering degree in Industrial Engineering and Management from Khulna University of Engineering & Technology. His research interests include smart manufacturing, green supply chain, lean manufacturing & six sigma, operation research, and Industry 4.0.

Abday Mohaimin is pursuing B.Sc. Engineering degree in Industrial Engineering and Management from Khulna University of Engineering & Technology. His research interests include smart manufacturing, artificial intelligence, digital transformation.

Abir Ahsan is pursuing B.Sc. Engineering degree in Materials Science And Engineering from Khulna University of Engineering & Technology. His research interests include manufacturing, artificial intelligence, engineering materials.

Kazi Md. Tanvir Anzum is a Lecturer in the Department of Industrial Engineering and Management at Khulna University of Engineering and Technology (KUET), Khulna, Bangladesh. He earned his B.Sc. Engineering degree in Industrial and Production Engineering from KUET. Currently, he is pursuing a master's degree in Industrial Engineering, further expanding his expertise in the field. Tanvir's research interests include supply chain management, health systems engineering, operations research, lean manufacturing, and system development in healthcare. Enthusiastic about operations research, he actively collaborates with researchers worldwide, contributing to high-quality journal articles and conference papers. With a passion for integrating innovative methodologies into healthcare and industrial systems, he aims to enhance efficiency and sustainability across these domains.

Syed Rafidul islam is a undergraduate student in the Department of Industrial Engineering and Management at Khulna University of Engineering and Technology, Bangladesh. His research focus is data science, operations research, supply chain management and product design.