International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 06 | June – 2025 DOI: 10.55041/ISJEM03936
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Disruptive Technological Innovations in Supply Chain Management: A Study of Selected Steel Industries in Chhattisgarh

Amity Business School, Amity University Chhattisgarh
Corresponding Email: akshat.bajpai1@s.amity.edu
Author's name - Akshat Bajpai
Co-author name - Prof Dr.Sumita Dave
Date: 30 May 2025

Abstract
The steel industry in Chhattisgarh, a significant contributor to India's metallurgical sector, is experiencing transformative changes driven by disruptive technological innovations in supply chain management. This study explores the adoption and impact of advanced technologies—such as the Internet of Things (IoT), blockchain, and additive manufacturing—within selected steel enterprises in the region. Employing a mixed-methods approach that includes case studies, stakeholder interviews, and data analysis, the research examines how these technologies enhance operational efficiency, transparency, and sustainability across the supply chain. Findings indicate that IoT facilitates real-time monitoring and predictive maintenance, blockchain ensures data integrity and traceability, and additive manufacturing brings production closer to end-users, potentially reshaping logistics structures. Despite these advancements, challenges persist, including integration complexities, skill gaps, and infrastructural constraints. The study underscores the necessity for strategic planning, workforce development, and supportive policies to fully leverage these innovations. By providing insights into the technological evolution of supply chain management in Chhattisgarh's steel industry, this research contributes to the broader discourse on industrial modernization and sustainable practices in emerging economies.

Keywords
Supply Chain Management, Steel Industry, Chhattisgarh, Industry 4.0,Internet of Things (IoT), Blockchain Technology, Additive Manufacturing, Digital Transformation, Sustainable Supply Chain, Green Supply Chain Management ,Smart Manufacturing, Operational Efficiency

Introduction

The steel industry is a cornerstone of industrial development, providing essential materials for infrastructure, transportation, and manufacturing sectors. In India, Chhattisgarh has emerged as a significant hub for steel production, housing prominent facilities such as the Bhilai Steel Plant and the Nagarnar Steel Plant. These establishments not only contribute substantially to the nation's steel output but also play a pivotal role in the regional economy.

In recent years, the global steel industry has been undergoing a paradigm shift, driven by the advent of disruptive technological innovations in supply chain management. Technologies such as the Internet of Things (IoT), blockchain, and additive manufacturing are redefining traditional supply chain operations, enhancing efficiency, transparency, and responsiveness. For instance, IoT enables real-time monitoring of equipment and inventory, blockchain ensures secure and transparent transactions, and additive manufacturing allows for on-demand production, reducing lead times and inventory costs.

Despite the global momentum, the adoption and integration of these technologies within Chhattisgarh's steel industry remain varied. Factors such as infrastructural limitations, workforce readiness, and investment capacities influence the extent and effectiveness of technological implementation. Understanding how these

disruptive innovations are being embraced by steel enterprises in Chhattisgarh is crucial for identifying best practices, challenges, and opportunities for improvement.

This study aims to explore the current state of disruptive technological adoption in the supply chain management of selected steel industries in Chhattisgarh. By examining the implementation strategies, operational impacts, and barriers faced by these enterprises, the research seeks to provide insights that can inform policy decisions, strategic planning, and future research in the domain of industrial supply chain innovation.

In summary, disruptive technological innovations hold significant promise for transforming supply chain management in the steel industry. For regions like Chhattisgarh, embracing these advancements could lead to enhanced competitiveness and sustainability, provided that the associated challenges are effectively addressed.

Literature Review

The steel industry has long been a cornerstone of industrial development, and its supply chain management practices are critical to operational efficiency and competitiveness. In recent years, the advent of disruptive technologies has begun to reshape traditional supply chain models, offering new avenues for optimization and resilience.

One such technology is the Internet of Things (IoT), which enables real-time monitoring and data collection across various stages of the supply chain. By embedding sensors in equipment and inventory, companies can gain insights into operational performance, predict maintenance needs, and reduce downtime. This level of visibility enhances decision-making and fosters a more responsive supply chain.

Blockchain technology is another innovation gaining traction in supply chain management. Its decentralized and immutable ledger system ensures transparency and traceability of transactions, which is particularly beneficial in complex supply chains like those in the steel industry. By recording every transaction securely, blockchain can help in verifying the authenticity of materials, tracking shipments, and ensuring compliance with regulatory standards.

Additive manufacturing, commonly known as 3D printing, is also influencing supply chain dynamics. By enabling on-demand production of components, it reduces the need for large inventories and allows for more localized manufacturing. This shift not only shortens lead times but also minimizes transportation costs and environmental impact.

In the context of Chhattisgarh's steel industry, the adoption of these technologies presents both opportunities and challenges. While the potential benefits include improved efficiency, cost savings, and enhanced sustainability, barriers such as high implementation costs, lack of technical expertise, and infrastructural limitations may hinder widespread adoption.

Furthermore, the integration of these technologies necessitates a strategic approach that includes workforce training, investment in infrastructure, and supportive policies. Collaborations between industry stakeholders, academic institutions, and government bodies can play a pivotal role in facilitating this transition.

In summary, disruptive technological innovations hold significant promise for transforming supply chain management in the steel industry. For regions like Chhattisgarh, embracing these advancements could lead to enhanced competitiveness and sustainability, provided that the associated challenges are effectively addressed

Methodology

This study aims to investigate the adoption and impact of disruptive technological innovations in supply chain management within selected steel industries in Chhattisgarh. To achieve this, a mixed-methods research design was employed, combining both qualitative and quantitative approaches to provide a comprehensive understanding of the subject matter.

Research Design

A descriptive research design was adopted to explore the current state of technological integration in supply chain processes. This approach facilitates the identification of patterns, relationships, and trends associated with the implementation of disruptive technologies in the steel sector.

Data Collection Methods

Primary Data Collection:

Structured Interviews: Key personnel from selected steel industries, including supply chain managers, IT specialists, and operations heads, were interviewed to gather insights into the implementation and effects of technologies such as IoT, blockchain, and additive manufacturing.

Questionnaires: A structured questionnaire was distributed to employees involved in supply chain operations to quantify the extent of technology adoption and its perceived impact on efficiency, transparency, and sustainability.

Secondary Data Collection:

Relevant literature, industry reports, and case studies were reviewed to contextualize the findings and compare them with global best practices in supply chain innovation.

Sampling Technique

A purposive sampling method was utilized to select steel industries in Chhattisgarh that have initiated or implemented disruptive technologies in their supply chain processes. This non-probability sampling technique ensures the inclusion of information-rich cases pertinent to the research objectives.

Data Analysis

Qualitative Data: Thematic analysis was conducted on interview transcripts to identify recurring themes and insights related to technological adoption, challenges faced, and strategic approaches employed by the industries.

Quantitative Data: Statistical analysis, including descriptive statistics and correlation analysis, was performed on questionnaire responses to determine the relationship between technology adoption levels and supply chain performance indicators.

Ethical Considerations

All participants were informed about the purpose of the study, and their consent was obtained prior to data collection. Confidentiality and anonymity were maintained throughout the research process to ensure ethical compliance.

Results and Analysis

This study investigates the integration of disruptive technologies—specifically the Internet of Things (IoT), blockchain, and additive manufacturing (3D printing)—into the supply chain management of steel industries in Chhattisgarh. The findings are based on primary data collected through structured interviews and surveys with key stakeholders from selected steel plants, including Bhilai Steel Plant and Nagarnar Steel Plant, as well as secondary data from industry reports and academic literature.

1. Internet of Things (IoT)
IoT technologies have been increasingly adopted to enhance real-time monitoring and predictive maintenance within steel plants. For instance, Bhilai Steel Plant has implemented sensor-based systems to monitor equipment performance, leading to a reduction in unplanned downtimes and maintenance costs. Similarly, Nagarnar Steel Plant utilizes IoT-enabled devices to track inventory and optimize logistics, improving overall supply chain efficiency.

2. Blockchain Technology
Blockchain has been explored for its potential to enhance transparency and traceability in the steel supply chain. While adoption is still in its nascent stages, pilot projects have been initiated to test its efficacy in tracking material provenance and ensuring compliance with quality standards. These initiatives aim to reduce fraud and improve trust among supply chain partners.

3. Additive Manufacturing (3D Printing)
Additive manufacturing is being considered for producing spare parts on-demand, thereby reducing inventory costs and lead times. However, its adoption faces challenges such as high initial investment and the need for skilled personnel. Despite these barriers, some plants are experimenting with 3D printing for prototyping and small-batch production, indicating a gradual shift towards more flexible manufacturing processes.

Challenges Identified
High Initial Investment: The cost of implementing these technologies remains a significant barrier, especially for smaller enterprises.

Skilled Workforce: There is a shortage of personnel with the necessary skills to operate and maintain advanced technological systems.

Integration with Legacy Systems: Existing infrastructure and legacy systems pose challenges in integrating new technologies seamlessly.

Regulatory and Standardization Issues: Lack of standardized protocols for data sharing and interoperability hampers the full potential of these technologies.

``

Discussion

The integration of disruptive technologies—specifically the Internet of Things (IoT), blockchain, and additive manufacturing (3D printing)—into the supply chain management of steel industries in Chhattisgarh has demonstrated significant potential for enhancing operational efficiency, transparency, and sustainability. This discussion synthesizes the findings from the study and contextualizes them within the broader landscape of technological advancements in the steel sector.

1. Internet of Things (IoT)
The adoption of IoT technologies in steel plants has facilitated real-time monitoring of equipment and inventory, leading to improved predictive maintenance and reduced downtime. For instance, Bhilai Steel Plant has implemented sensor-based systems to monitor equipment performance, enabling timely interventions and minimizing production disruptions. Similarly, Nagarnar Steel Plant utilizes IoT-enabled devices to track inventory and optimize logistics, improving overall supply chain efficiency.

2. Blockchain Technology
Blockchain has been explored for its potential to enhance transparency and traceability in the steel supply chain. By providing a decentralized and immutable ledger, blockchain ensures the authenticity of transactions and the provenance of materials. This is particularly crucial in the steel industry, where the complexity of supply chains and the risk of counterfeit materials pose significant challenges. The integration of blockchain with IoT systems further strengthens supply chain resilience by enabling secure and real-time data sharing among stakeholders.
3. Additive Manufacturing (3D Printing)
Additive manufacturing has introduced new paradigms in spare parts production and inventory management within the steel industry. By enabling on-demand production of components, 3D printing reduces the need for extensive inventories and minimizes lead times. This capability is particularly beneficial in the steel sector, where the demand for specific parts can be unpredictable, and traditional manufacturing methods may not be cost-effective. Moreover, the integration of blockchain with additive manufacturing ensures the traceability and authenticity of 3D printed components, addressing concerns related to quality and compliance.

Challenges and Barriers
Despite the promising benefits, the adoption of these technologies in Chhattisgarh's steel industry faces several challenges:

High Initial Investment: The cost of implementing these technologies remains a significant barrier, especially for smaller enterprises.

Skilled Workforce: There is a lack of skilled personnel capable of operating and maintaining advanced technological systems.

Integration with Legacy Systems: Existing infrastructure and legacy systems pose challenges in integrating new technologies seamlessly.

Regulatory Hurdles: The absence of standardized protocols and regulatory frameworks can impede the seamless adoption of these technologies.

Addressing these challenges requires a concerted effort from industry stakeholders, including policymakers, to create an enabling environment for technological adoption.

Strategic Recommendations
To harness the full potential of disruptive technologies in the steel supply chain, the following strategies are recommended:

Investment in Workforce Development: Training programs should be established to equip employees with the necessary skills to operate and maintain advanced technologies.

Public-Private Partnerships: Collaborations between government bodies and private enterprises can facilitate the sharing of resources and knowledge, accelerating technology adoption.

Standardization Efforts: Developing standardized protocols for data sharing and system interoperability can enhance the efficiency and effectiveness of technology integration.

Policy Support: Government incentives and subsidies can alleviate the financial burden associated with technology adoption, encouraging more enterprises to invest in innovation.

Conclusion

This research has explored the integration of disruptive technologies—specifically the Internet of Things (IoT), blockchain, and additive manufacturing (3D printing)—into the supply chain management of steel industries in Chhattisgarh. The findings indicate that these technologies have the potential to significantly enhance operational efficiency, transparency, and sustainability within the sector.

The adoption of IoT technologies in steel plants has facilitated real-time monitoring of equipment and inventory, leading to improved predictive maintenance and reduced downtime. Blockchain technology has been explored for its potential to enhance transparency and traceability in the steel supply chain. Additive manufacturing has introduced new paradigms in spare parts production and inventory management within the steel industry.

However, the implementation of these technologies is not without challenges. High initial investment costs, a shortage of skilled workforce, and integration complexities with existing systems have been identified as significant barriers. Addressing these issues requires concerted efforts from both industry stakeholders and policymakers.

In conclusion, while the integration of disruptive technologies presents promising opportunities for the steel industry in Chhattisgarh, overcoming the associated challenges is crucial for realizing their full potential. Future research should focus on developing strategies to mitigate these barriers and facilitate the seamless adoption of these technologies across the sector.

References

1-Hong, L., & Hales, D. N. (2024). How blockchain manages supply chain risks: Evidence from Indian manufacturing companies. International Journal of Logistics Management.
ResearchGate

2-Zhang, H. (2021). Blockchain facilitates a resilient supply chain in steel manufacturing. Coventry University Research Portal.
Coventry University

3-Sharma, H., Garg, R., Sewani, H., & Kashef, R. (2023). Towards a sustainable and ethical supply chain management: The potential of IoT solutions. arXiv Preprint.
arXiv

4-Singh, M. (2025). India's steel industry is forging the future of global manufacturing. Manufacturing Today India.
Manufacturing Today India

5-PWC India. (2020). The Indian steel industry: Growth, challenges and digital disruption. PWC India.
PwC

6-Tata Nexarc. (2025). Supply chain challenges in steel industry in India. Tata Nexarc Blog.
Tatanexarc Blog

7-Zupyak. (2023). Disruptive technologies: Reshaping the steel industry. Zupyak.
Zupyak